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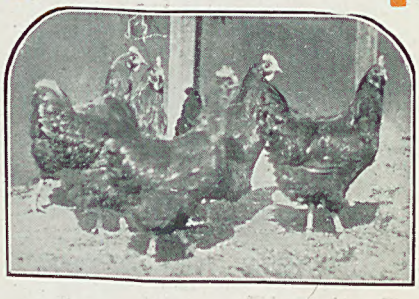

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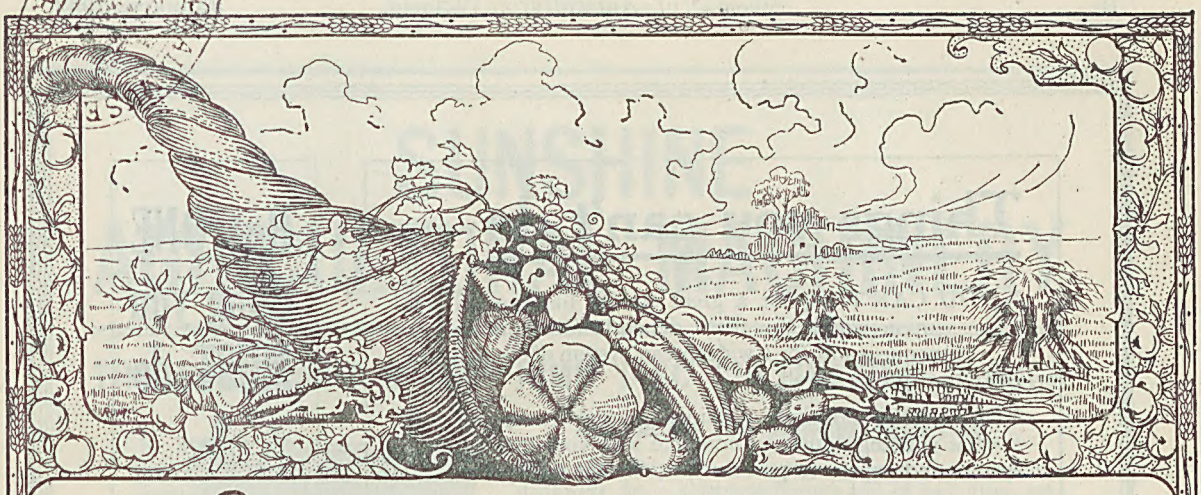

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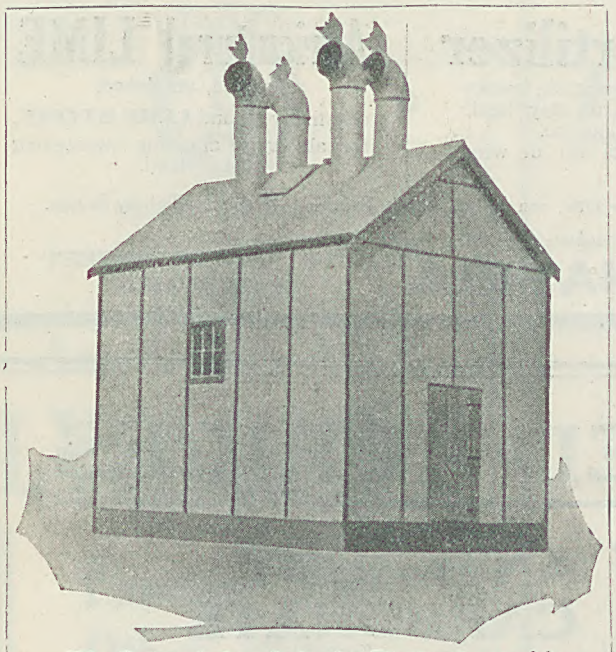

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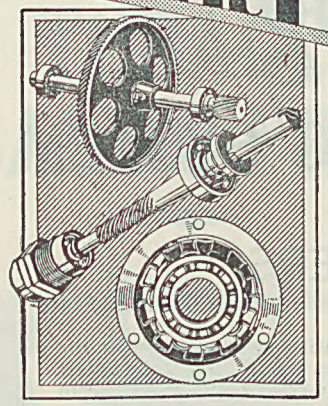

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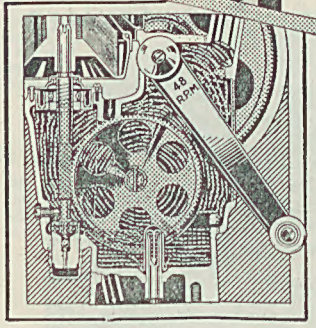

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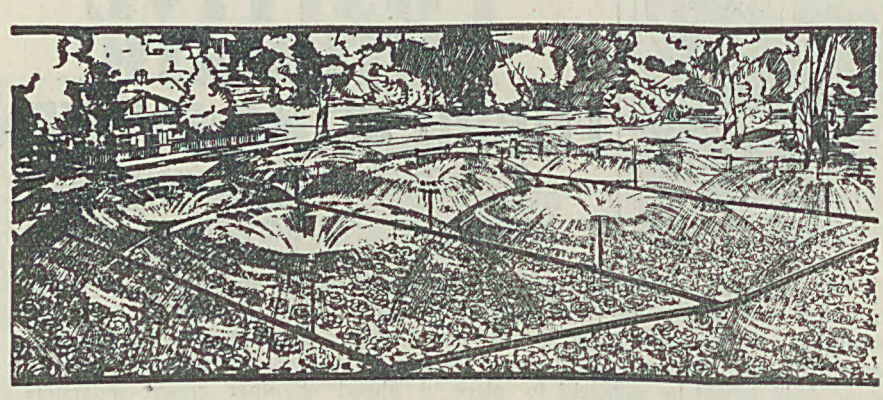

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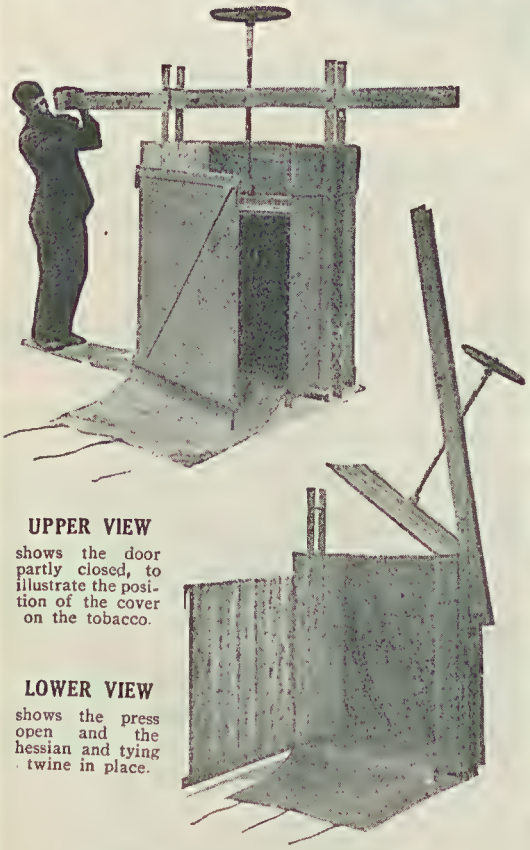

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Defiance Blowfly Oil

THE SHELL COMPANY LIMITED

D.O. 25

The Journal of the DEPARTMENT of AGRICULTURE of VICTORIA

Overseas Fruit Markets

Requirements Further Analysed

By E. Meeking, Senior Fruit Inspector.

IN the October number of this Journal, an analysis was made of some of the requirements considered necessary for placing Victorian fruit in the best possible condition on the overseas markets. It was stated, amongst other things, that if our apples were carefully harvested, packed, and transported, selected for uniformity in colour, and at a stage of maturity to ensure a continuation of the ripening processes, and were pre-cooled to a sufficiently low temperature to ensure that the machinery on the transporting ship would be enabled to maintain a uniform temperature in the hold within a few degrees around 32° or 33° Fahr., the writer believed that most of the causes for the complaints now received regarding the appearance and condition of the fruit would be removed. In support of this, it may be stated that although the benefits of organized methods of harvesting, packing, and pre-cooling shipments of apples had never been commercially demonstrated in Australia, yet the appearance and condition of fruit which the writer saw on overseas markets, shipped from countries which had been applying these methods for some years, were convincing evidence of the benefits derived therefrom.

The factors which most closely relate to the successful production and preparation of fruit for marketing are suitability of soil and climate in association with facilities for grading, packing, handling, pre-cooling, transporting, and accessibility to markets.

Let us take these in their order, and, from the stand-point of each, compare this country with those which produce fruit in competition with ours on the overseas markets.

Physical and Climatic Advantages.

Physically and climatically, the apple and pear-growing areas in Australia possess many advantages over areas devoted to the same purposes in many other countries. The soil, though varied, is generally good, and this is supplemented by good average rainfall, abundant sunshine, and equable climate, devoid of the extreme ranges in temperature associated with many of the apple-growing areas of North American and European countries where, in the winter, the temperature sometimes falls to many degrees below zero.

In flavour and quality competent experts consider that our best varieties of apples and pears are possibly unequalled; but, unfortunately, we are not doing them or ourselves justice by neglecting to prepare them for market in the manner which their general excellence deserves.

Apart from the drawbacks of extremes in temperature, the Pacific States, Western

Canada, and New Zealand enjoy certain advantages connected with the production of apples and pears which are not fully shared by Australia as a whole. In the States of Washington and Oregon the fruit is grown in wide valleys with a plentiful supply of water furnished in each valley by a river running down the centre. The construction of dams above the orchards towards the head of the valleys enables the fruit to be grown under irrigation, which, in conjunction with a uniformity of soil, contributes to a uniform production in the matters of quantity and quality. New Zealand possesses great advantages in possessing rich and uniform soil and little extreme range in climate, as apples and pears are grown in both the North and South Islands.

A typical country Packing Shed and Cool Stores.

In all the countries mentioned, the problem of irregular bearing does not seem so acute as in most of the Australian States; nor do the fruit-growers in those countries appear to suffer so acutely from the periodic invasion of thrip as do the fruit-growers in some parts of Australia.

Handicaps to Organization in Australia.

Concerning facilities for grading, packing, handling, and transport, Australia, as a whole, is handicapped in the matter of organizing the fruit-growers on the plan successfully adopted by the citrus-growers of California and apple-growers of British Columbia, whereunder local packing units are affiliated with district exchanges, which in turn are represented in a central exchange. This handicap exists through the scattered nature of the apple and pear-growing areas in Australia, which are isolated from each other by intervening distances ranging from hundreds to thousands of miles. For the same reason organization on the lines on which the fruit-growing industry of New Zealand has developed during recent years presents some difficulty. In that country the export of apples and pears is governed by a Control Board, appointed under legislative enactment, and consisting of seven members—two nominated by the Government and five elected by the growers. Under this scheme the Board may take full control of shipping, transport, and marketing arrangements, but cannot buy or own fruit.

In the opinion of the writer, organization in Australia will have the best chance of developing to success if it commences independently in each State on lines to suit local requirements, with perhaps a gradual extension to Australia as a whole until finally united under central control. This report is concerned mainly with the development of the fruit industry in Victoria, and the possibilities of successfully establishing a State-wide organization for the production and preparation of a standardized pack may now be examined on available evidence from the stand-points of facilities for grading, packing, handling, pre-cooling, and transport, and accessibility of markets.

The map reproduced here shows the chief apple-growing districts in Victoria, while the accompanying tables give for each district:—(*a*) the railway stations, with the total quantity of apples and pears loaded at each station during the 1930 export season; (*b*) the number of growers; (*c*) the total cool storage capacity; and (*d*) the number of packing sheds.

The map shows that, with respect to the important matters of easy transport and ample cool storage facilities, Victorian fruit-growers probably are better served than those of any other State, and perhaps as well served as the fruit-growers in any country in the world. The same cannot be said regarding soil and climatic conditions, as these vary considerably in different parts of the State, but all of the districts in which apples and pears are grown are more or less adapted for raising varieties suitable for export.

Map of Victoria showing chief apple-growing districts and cool-storage accommodation.

The outstanding features disclosed by the map and accompanying tables are:—(1) The furthest loading station is only slightly over 200 miles from the port of shipment, as against 3,000 miles or more from the Pacific slope to the Atlantic sea-board, and more than 1,000 miles in South Africa. (2) Of the total of 1,025,265 cases of apples and pears shipped to the United Kingdom and Europe in 1930, approximately 80 per cent. was grown within 50 miles; 60 per cent. was grown within 100 miles; and only 20 per cent. was grown over 100 miles from the port of shipment. (3) Approximately 75 per cent. of the total was grown in districts with local cool storage accommodation, and 25 per cent. with no such accommodation. (4) Approximately 76 per cent. of the total was from districts with packing shed accommodation, and 24 per cent. from districts with no such accommodation. (4) Practically all districts which have packing house accommodation have cool storage accommodation also, and vice versa. The only two exceptions to this rule are—Bendigo (16,737 cases), which has cool storage, but no packing house; and Quantong, which has a packing house, but no cool store. (5) Some districts have too many packing houses, and some have none. (6) With the exception of Portland, the districts unprovided with facilities for both centralized packing and pre-cooling are all situated more than 100 miles from the port of shipment. (7) At least 90 per cent. of apples and pears exported overseas from Victoria are grown in districts where the orchards are sufficiently close to each other to produce successfully a standardized community pack of the highest possible commercial value.

Pre-cooling.

It is shown that ample facilities exist for pre-cooling all fruit shipped from Victoria overseas, but although the growers in many of the largest fruit-growing areas in other countries for some years have accepted the fact that all fruit, including apples, intended for long-distance transport should be cooled as promptly as possible after picking, the question of whether the slight added cost would be justified is still, strange to say, a controversial one in Australia. For this reason, and

GOVERNMENT COOL STORES.

DISTRICTS WHERE THERE IS NO COOL STORE ACCOMMODATION.

District.	Number of Growers.	Quantity Loaded.	District Loading.	Miles from Melbourne.
Amphitheatre	35	33,213		136
Elmhurst	8	5,049		145
Crowlands	5	1,857	43,844	148
Lexton	4	1,545	A	*105
Lamplough	4	1,306		*124
Eversley	1	874		148
	57	43,844		
Longwarry	1	482		51
Drouin	15	34,046		57
Warragul	5	14,092	51,298	61
Nilma	1	1,601	F	63
Rokeby	1	1,077		70
	23	51,298		
Bairnsdale	11	16,555		170
Mossiface	1	460	17,215	189
Farago	1	200	G	..
	13	17,215		
Pomonal	14	59,217		164
Stawell	9	13,255		150
Ararat	3	1,500	75,055	131
Great Western	2	382	H	142
Buangor	1	501		117
	29	74,855		

District.	Number of Growers.	Quantity Loaded.	District Loading.	Miles from Melbourne.
Horsham	5	2,365		203
*Quantong	15	20,640		214
Remlaw	1	3,357	29,559	210
Nhill	1	3,197	I	248
	22	29,559		
Bacchus Marsh	21	28,911		32
Riddell	2	2,622		35
Sunshine	1	399	34,863	8
Emerald	2	1,764	J	32
Gembrook	2	1,167		41
	28	34,863		
Barwon Downs	1	639	639	99
	1	639	R	
Cranbourne	3	5,227	5,427	27
Yinnar	1	200	S, S (*a*)	96
	4	5,427		
Huon	2	994	1,294	201
Kiewa	1	300	T	205
	3	1,294		
Total Growers ..	180			

Total (c/s) 258,994.

* Packing house.

DISTRICTS WHERE THERE IS COOL STORE ACCOMMODATION.

	District.	Number of Growers.	Quantity Loaded.	District Loadings.	Number of Packing Sheds.	Number of Cool Stores.	Capacity of Cool Stores.	Miles from Melbourne.
	Harcourt ..	97	108,901					83
	Elphinstone ..	22	32,266					70
B	Castlemaine ..	2	3,250	149,800	3	1	80,000	78
	Sutton Grange	2	1,950					80
	Campbell's Ck.	6	3,433					81
		129	149,800					
	Bendigo ..	7	4,645					101
C	Sedgewick ..	7	6,469	16,737	..	1	10,000	114
	Strathfieldsaye	4	5,623					107
		18	16,737					
	Beaconsfield	7	9,569					29
	Beaconsf'ld Up.	20	17,015					29
D	Narre Warren	24	45,687	214,061	6	5	82,800	25
	Officer ..	10	26,880					31
	Pakenham ..	88	114,910					36
		149	214,061					
	Nar-nar-goon	6	14,315					40
	Bunyip ..	14	11,346	50,490	2	2	12,118	49
E	Garfield ..	10	19,125					46
	Tynong ..	3	5,704					43
		33	50,490					
	Arthur's Creek	24	15,002					30
	Diamond Creek	4	681					20
	Hurstbridge ..	12	5,292					23
	Nutfield ..	4	2,275					
	Panton Hill ..	8	812	34,858	2	13	104,800	23
M	Strathewan ..	5	6,196					
	Whittlesea ..	6	3,242					26
	Yan Yean ..	1	270					22
	Cottle's-bridge	2	1,088					
		66	34,858					
	Somerville ..	58	27,740					34
	Red Hill ..	34	21,814					52
	Tyabb ..	54	20,471					37
	Hastings ..	32	16,241					40
	Merricks ..	3	6,702	100,437	5	5	135,000	48
K	Mooroduc ..	7	5,240					35
	Morningt'n Pen.	1	985					39
	Flinders ..	1	1,058					57
	Bittern ..	1	135					42
	Baxter ..	1	51					32
		192	100,437					

	District.	Number of Growers.	Quantity Loaded.	District Loadings.	Number of Packing Sheds.	Number of Cool Stores.	Capacity of Cool Stores.	Miles from Melbourne.
	Ardmona ..	3	1,626					115
	Graham Vale	2	148					115
L	Lancaster ..	2	1,510					129
	Mooroopna ..	1	1,259	8,947	2	2	91,000	110
	Shepparton ..	22	3,384					113
	Tongala ..	3	1,020					131
		33	8,947					
	Balwyn ..	2	2,334					8
	Blackburn ..	23	19,681					11
	Box Hill ..	12	2,451					9
	Doncaster ..	42	51,306	105,076	7	12	370,100	13
N	Mitcham ..	3	11,145					13
	Ringwood ..	31	14,591					15
	Templestowe	3	1,653					15
	Warrandyte ..	2	1,915					30
		118	105,076					
	Black Flat ..	8	3,588	9,447	1	3	68,420	10
O	Burwood ..	5	3,372					8
	Wheeler's Hill	1	2,487					16
		14	9,447					
	Bayswater ..	6	1,272					19
	Croydon ..	30	20,751					19
	Kilsyth ..	4	394					20
	Lilydale ..	5	3,755					24
	Montrose ..	2	57					22
P	Scoresby ..	2	1,873	31,574	1	4	77,200	19
	Silvan ..	1	83					34
	Vermont ..	2	1,152					16
	Wandin ..	2	596					31
	Mt. Evelyn ..	3	991					28
	Wanturna ..	1	650					
		58	31,574					
	Healesville ..	3	15,505	15,517	1	1	17,000	59
Q	Steel's Creek	1	12					36
		4	15,517					
	Gorae ..	13	18,231					247
U	Heywood ..	5	7,668					235
	Portland ..	6	3,876	30,127	1	1	15,000	252
	Milltown ..	1	352					228
		25	30,127					
	Total Growers	839		767,071	31	50	1,023,438	

because of its great importance, the matter will not now be fully discussed, but will be made the subject-matter for an article in a later issue of this *Journal;* when evidence from authoritative sources in favour of precooling will be reviewed.

Comparative Transport Costs.

Despite a widespread impression to the contrary, Australia is not more unfavorably situated with respect to transport distances and costs than many other apple and pear-growing countries which ship these fruits to the European markets. While Australia is further from Europe than either British Columbia or South Africa, the inland transport distances are considerably less, and in the case of New Zealand, the ocean transport distance exceeds that from Australia.

The following table shows the comparative distances, times occupied in transit, land and ocean freight charges, and average value of fruit in relation to total costs of freight from British Columbia, South Africa, New Zealand, and Australia to the United Kingdom and Europe.

The freight charges on fruit from California, Washington, and Oregon are similar to those from Canada.

In view of the foregoing facts, and considering the length of time that apples and pears have been grown in Australia, it may well be asked why the growers of these fruits, particularly in Victoria, have not availed themselves of the great natural advantages of soil and climate, and which have been further added to by the widespread erection of cool storage accommodation—but have missed the opportunity that existed until recent years of supplying a pack of high commercial repute, a pack which would have created a widespread demand before the competition from South Africa, New Zealand, and cool stored fruit from America, had begun to make itself felt? For some years before, during and after the war, this policy could have been carried into effect without challenge, but the growers apparently were content to stand by and watch the gradual absorption of a trade by their competitors. It must be remembered that the competition of stored fruit from the United States of America is more to be feared than any other, as this represents the spill over from home consumption of far the largest apple-producing country of the world.

The apparent apathy of the growers, not only of Victoria but of Australia generally, may be attributed to the following:—(1) The sole possession, without much preliminary effort, of the overseas market for many years, when our apples and pears met no competition and for the period of their shipment and arrival supplied a much-needed want. Under those circumstances, brokers and merchants on the Continent and in the United Kingdom were glad to receive our fruit irrespective of whether or not it was graded and packed in accordance with standardized methods, and the prices received generally were so satisfactory that the fruit-growers, beyond occasional losses arising from deterioration of consignments during transit, usually realized a good margin of profit on each season's transactions; and (2) the easy finance obtained by growers through their local agents from the overseas brokers and private treaty salesmen during the pre-war and war periods, and for some years after the war, when advances to growers were readily made on fruit shipped on consignment to cover cost of packing and transport, plus 3s. or 4s. per case.

Under these conditions fruit-growers were not induced to cultivate the spirit of service which is the only basis on which any business can be permanently maintained, nor was any inducement created for setting up orderly and controlled arrangements in connexion with

Country.	Maximum Distance from Overseas Market.		Average Freight Charges.		Length of Voyage.		Percentage of Freight Value.
	Inland.	Ocean.	Inland.	Ocean.	Inland.	Ocean.	
	miles.	miles.	*s. d.*	*s. d.*	days.	days.	
British Columbia ..	3,000	3,000	3 1½	1 3	11–14	9–11	33
South Africa	1,110	..	5d. to 7d.	..	3–5	17–21	22
New Zealand	150	14,000	5d. to 8d.	4 0	2–3	40–45	33
Australia	300	12,000	6d. to 1s.	3 6	2	37–40	33

financial advances on each season's crop. Within the past few years circumstances have completely changed. Under the stress of competition here and abroad transactions between the agent for the overseas salesmen and the grower are sometimes made on the basis of a straight-out purchase of one-half the crop at a fixed f.o.b. or c.i.f. and e. price; the other half to be shipped on consignment at grower's risk. That such a system is undesirable goes without saying. On this matter, the Report of the Imperial Economic Committee contains, amongst other things, the following statements:—

"From advances to cover the bare cost of the ocean freights this system has grown so that the advances are now sufficient to meet the cost of packing and shipment, and in some cases even a portion of the expenses of harvesting. It has even gone further, to the point where the broker has on occasion bought a half interest in the fruit, which is then shipped, not on consignment, but on the joint account of shipper and broker. Sometimes the fruit has been bought outright by the broker. So it happens that on the same day it is quite possible that a broker may have for sale at the United Kingdom port consignments of fruit in which he is interested in three different capacities—as salesman without advances made, or salesman with advances, or as part or whole owner. This diversity of interest, in the case of salesmen who put themselves forward as the representatives of the shipper, is undesirable, and we think that the practice in the United Kingdom should conform to that in certain continental countries, where brokers are compelled by municipal or other regulations to confine their activities to their proper function."

Judging by the advices received from overseas as to the low prices realized for a large proportion of the fruit which has been shipped each season, one naturally would consider that no salesman in the United Kingdom could afford to make any f.o.b. offer to purchase consignments on a 100 per cent. basis at a price which would even cover cost of production.

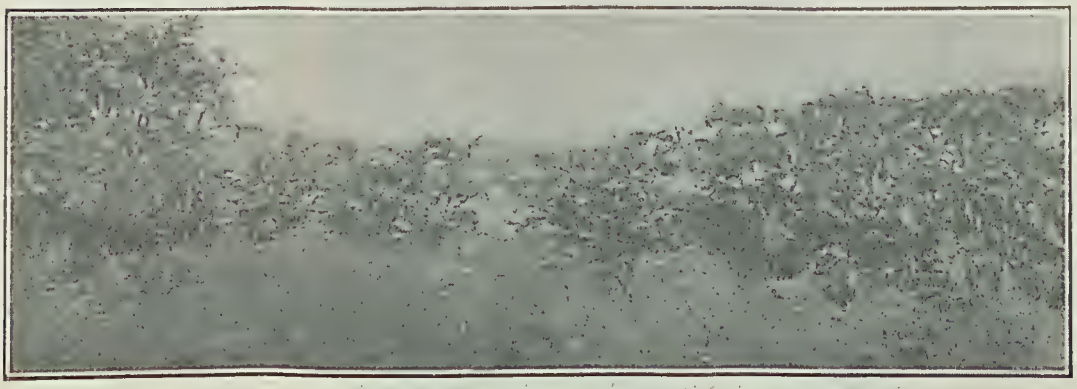
The thanks of the writer are tendered to Messrs. Keys and Aldous for assistance in compiling the map and tables.

Grading and Packing Apples—Somerville Fruit Packing Shed.

Degeneration in Potatoes

Virus Diseases and their Control

By D. B. Adam, B.Agr.Sc., Plant Pathologist.



Three virus affected plants with healthy plants at each end of the row.

A POTATO variety sometimes fails to produce a satisfactory yield even when it is grown under favorable conditions. The soil conditions may be as favorable as those at Koroit, the rainfall may be as satisfactory as that at Trentham, and the crop may be quite free from fungus diseases such as Irish Blight, Dry Rot, or Rhizoctonia, and yet it does not yield well. Such a variety probably is degenerate or "run out."

Degeneration, as described, is no new thing. One of the harmless diversions of our elders is to sigh for the good old days when potatoes always grew to perfection, and produced 10 tons per acre in land that had been given the roughest preparation. But historical facts do not support them. From the earliest time that potatoes were first grown as a field crop, some 150 years ago, to the present day, degeneration, in varying degrees, has dogged the footsteps of potato-growers. We read how a Mr. Hunter, in 1773, had seen potatoes so run out that they hardly returned a treble of the seed used. To-day practically every crop grown shows evidence of some degree of degeneration.

Two explanations have been offered. The first assumes that potatoes, being reproduced time after time from sets rather than from true seed, become old and worn out. The second explanation is based on the fact that a degenerate stock contains a proportion of plants bearing curled, crinkled, and mottled leaves which produce either a few large spindly tubers or a lot of small unsaleable ones. All these are symptoms of definite diseases that can be conveyed from diseased to healthy plants—we call them virus diseases. This second explanation then simply asserts that degeneration is due to the progressive infection of a potato stock by disease.

Let us consider these two theories. Firstly, there is the theory of senility. The tuber or so-called "seed" of the potato is simply a kind of underground stem. The continued propagation from tubers is merely an extension of the vegetative life of the plant, and we, human like, are inclined to argue that since we ourselves grow old and less vigorous, potatoes do likewise. We think this way in spite of the willow trees by the river side that have been propagated by cuttings since time immemorial, and yet show no sign of senility. We find that several potato varieties "run out" more quickly than others, although most commercial varieties remain in cultivation for 20 to 30 years. Myall's Ashleaf, a variety which is more than 150 years old, is still grown in parts of England. Some varieties have degenerated within ten years, while others again have "run out" before they could be raised in sufficient quantity for

A Healthy Plant (Variety—Brown's River.)

commercial usage! Finally, I would mention a variety called "Yam," which is still grown in the Orkney Islands off the coast of Scotland, although it is 150 years old. When brought south extreme degenerency overtakes it within two to three years. These facts cannot be accounted for on the theory of senility alone.

There is one other fact which is held by some to support the theory of senility. That is the fact that "seed" tubers dug in an immature state, produce heavier crops than ripe seed from the same crop. Experiments conducted by Mr. J. T. Ramsay, the Potato Expert of this Department, have demonstrated this fact clearly. Mr. Ramsay has found in his trials that the use of immature seed results in an average increase of yield of about 20 per cent.; occasionally he has obtained a 60 per cent. increase; in other cases the increase is only 7 per cent. or 8 per cent. Some people attempt to explain these undisputed facts on the ground that "seed" when dug green and immature still retains the vigour and virility of youth—a quality that it transmits to the crop subsequently raised from it. But why, we might ask, is the increase due to the immature seed so variable in different stocks of the same variety, when all stocks must of necessity be of the same age, having been derived from a common origin? Secondly, if this theory were true, should not the varieties longest in cultivation, hence the most senile, be those that show the greatest benefit from the use of immature seed? No such relationship is evident. Further remarks on this subject are reserved till later. The second explanation that I mentioned, the idea that potato degeneration is due to the infection of an increasing number of individual potatoes in a stock by distinct group of diseases, so-called virus diseases, provides an entirely satisfactory explanation of the facts of degeneration and such related facts as the increases in yield obtained by the use of immature seed.

All good growers of seed know the value of selection. The departmental potato trials conducted over the last eighteen years have all indicated the importance of seed selection. The value of selection indeed is beyond dispute. However, selection must be made with some guiding principles. Because, as I hope to show, the presence of virus disease in potato stocks is responsible for their running out and degeneration in yielding capacity, I think that growers anxious to select seed intelligently must know a few facts concerning these virus diseases.

We do not know exactly what a virus is, although we do know something about its behaviour within the growing plant. It occurs in the sap of a diseased plant, and may be carried from it to a healthy plant by sucking insects, especially green aphides. In this regard there is some similarity with malaria in man, this disease being spread by a certain kind of mosquito first biting a diseased person, taking some of the diseased blood and injecting into the next healthy person it bites.

Recent investigations have shown that a great variety of symptoms with which the observant

grower is familiar are actually symptoms of one or other virus disease. In some cases the leaves are curled, crinkled, ruffled, mottled, and spotted, or the stems may be dwarfed and streaked. The tubers may be affected in size or in numbers, be spindly, rough in the eye, pointed, cracked, or when they start to grow remain hard, produce small tubers or thin spindly sprouts. All these conditions are symptomatic of virus disease. "A badly rolled plant," it has been observed,* "is a pitiful object; it is small and stunted, and its leathery leaves rattle in the wind," while its yield is small and negligible.

Before proceeding further, I will indicate briefly some of the evidence which, I think, proves that potato degeneration, or at least the greatest part by far, is due to the spread of virus disease infection in a stock.

Brown's River potato plant with Mosaic, a virus disease.

Let us put two questions to the test of this theory. Will it explain the undoubted fact that in many places immature seed yields better than ripe seed; and, secondly, can we by applying our knowledge of these virus diseases, and that alone, recapture the original yielding qualities of a degenerate strain? Surely if we can answer yes to this last question it is decisive.

Although the use of immature seed generally does lead to increased yield this fact is not universal. In Northern Scotland there is none, or, at best, only a slight increase results. In these areas observation has shown that there is little or no virus disease present, and the rate of spread of these diseases is negligible. In England and in most parts of Ireland under ordinary conditions benefits as great as those discovered locally arise from the use of immature seed, and virus diseases are abundant in these districts.

Experiments conducted in these English and Irish districts have afforded convincing proof that, where potatoes are protected from virus disease infection, immature seed gives no better results than ripe seed. Other experiments have shown that there is a very clear relationship between the current season infection with virus disease and the increase obtained from the use of immature seed. In other words, the greater the amount of the present season infection the greater the benefit to be derived from the use of immature seed. The explanation of this benefit lies in the fact that virus disease, once contracted by the foliage, takes an appreciable time to pass down into the tuber and so affect the vigour of next year's plant, immature seed then being dug before the virus has had time to pass into the tuber.

In the second place, can we recapture the lost productivity of a variety? There are a number of cases where this has been done, but we can quote only one example here.

The variety "Champion" was raised from seed sown in Ireland by John Nichol in 1863. When first raised, it was extraordinarily vigorous, high yielding, and blight disease

* K. M. Smith, *Jour. Min. Agr.* (England) 37 : 3 : 226.

resistant. By 1886 nearly 80 per cent. of Ireland's potato acreage was planted to "Champions." By 1926, however, the proportion had fallen to 22 per cent. In 1924 Davidson, of the Irish Department of Agriculture, selected tubers for their freedom from virus disease, and grew them under conditions unfavorable to the spread of these diseases. By 1927 he had built up a stock with a yielding capacity and quality similar to that which the main stock had in 1877 at the height of its popularity.

As Dr. Salaman, the English potato authority, has described it: "Varieties know nothing of old age; it is to disease and not to fatigue or senility that they ultimately bow their heads and pass out of sight."

The basis of control of these diseases is selection. This method, of course, is not new. But the principle by which selection is guided is of recent date. We must select with a view to eliminating and maintaining stocks free from virus disease.

The Department's many experiments in recent years have demonstrated the value of seed selection. In these tests the plants were selected on the eminently sound plan that a healthy potato plant capable of producing seven or more good tubers was worth increasing. By this means increases in yield of from 25 to 30 per cent. were obtained. By adopting these standards which have no direct reference to virus disease the experimenter probably was eliminating plants whose mother "sets" were infected with virus, because such sets would not produce perfectly healthy vigorous foliage and would produce only rarely seven or more good tubers.

However, with this system there is the fact that plants infected with the disease in the current season, especially late in the season, would be included in the selected sample for the reason that the foliage would not show symptoms of disease, nor would the tubers be affected either in size or in number. The possibility of this occurring is indicated by Mr. Ramsay's experiments at Millbrook in the Ballarat district in 1923-24, where immature selected "seed"—that is seed dug before much virus infection had occurred in the season 1922-23—yielded from 7 per cent. to 11 per cent. better than did similarly selected mature seed; that is, seed left in the ground until a greater proportion of the infection contracted in the 1922-23 season had passed down into the tuber.

It is possible that in some localities a combination of selection along the lines indicated and the use of immature seed might, in a few years, eliminate virus disease infection. Great emphasis must be laid on the fact that these diseases are conveyed from plant to plant by insects. Any condition that retards or prevents the development of these insects will indirectly control the spread of virus diseases. These insects are absent or rare in the North of Scotland, Sweden, and the

Spindly sprout—a symptom which frequently accompanies leaf roll (Heald).

Northern States of North America, which are the districts where potatoes degenerate most slowly, and the districts from which neighbouring countries draw their seed. It is the reputation of these districts, all of which are cold, that is responsible for the time-honoured custom of obtaining a change of seed from a colder district. Apart from the fact that in cool districts these insects are less prevalent than in warm districts, we know little about their distribution. For instance, where climatic conditions are similar,

they may be less prevalent on peaty soil than on heavy clay soils; but this, with other possibilities, awaits investigation.

We can now indicate broadly the steps necessary in controlling these diseases. In the first place, successful permanent selection can be made only in districts comparatively free from sucking insects. For example, it would be hopeless to attempt growing potatoes for seed at the Burnley Gardens. The rate of spread there is extraordinarily rapid. I do not think that with the most rigid selection one could maintain a virus susceptible to potato stock in any reasonable state of productivity, although selected seed direct from Millbrook generally grows well the first season.

However, it is not sufficient merely to grow "seed" potatoes in bulk in a cool district. Spreading, to be sure, may be slower in such districts, but it occurs nevertheless, and must be checked. It is necessary to secure, by selection, a seed stock that has as little virus disease infection as possible, at least less than a total of 5 per cent. There should be a sufficient quantity to produce the seed requirement of the farm in a normal year, and this should be planted in a paddock isolated as far as possible, but at least 5 chains, from the nearest area of potatoes. The object of this is to prevent insects from outside the plot bringing in disease from unhealthy potatoes. The area, too, must be kept free from weeds, especially weeds like Black Nightshade, which may carry these diseases. The select plot should be examined as soon as the plants appear above ground, and any plants showing foliage abnormality, small leaves, puckering or curling, removed immediately. The area should be "rogued" in this way at least thrice before flowering time. After that no fresh disease symptoms will appear. This produce is lifted and used for bulk planting the next season. If the stock used the first season was a good one, and the district, by virtue of its comparative freedom from insects, a good one for seed growing, the succeeding bulk crop should be practically free from virus disease. It is, however, desirable to rogue it at least once.

The need for action along these lines is shown by the official Victorian statistics, which disclose that the average potato yield for the period 1921-29 was 2.76 tons per acre; for 1890 and 1900 it was 3.26 tons per acre.

Potato Plant (Aaran Victory) with Leaf Roll—one of the virus diseases. Note the curling of the leaves.

Potato Experiments

Results of Tests, 1930-31

By J. T. Ramsay, Potato Expert.

Warragul.

THE results of the potato trials conducted at Warragul for 1930-31 show that, for the fifth year in succession, the dressing of 6 cwt. of super. and 1 cwt. potassium sulphate per acre gave by far the best return after taking into consideration the cost of the fertilizer. A curious feature is that where ammonium and potash together are used with super. as a potato manure in Victoria, the resulting crop is not so good as where they are used separately with super. At the present time an explanation of this cannot be given.

At Warragul, as in all other potato tests in Gippsland, 6 cwt. per acre seems definitely to be the most beneficial rate of application for superphosphate. The range of increases during the past season is from 53 per cent. in the case of basic phosphate (6 cwt.) to 142 per cent. in the case of super. and potash together. It will be noted that the increases are constant and appreciable with each manurial treatment. As at Childers, the rate of application of market garden manure and basic phosphate was raised two years ago—in each case from 3 cwt. to 6 cwt. per acre. At Warragul these two manures are not showing to the same advantage as they are at Childers. Nevertheless, they are giving fair returns.

The yields for the 1930-31 season, together with the average returns for the five years the trials have been conducted, are shown in Table I. These plots are located on a medium red loam on the farm of Mr. S. Adkins.

The previously mentioned alterations in the rates of application of market garden and basic phosphate manures preclude the calculation of a five years' average for these dressings, but the results of the super. ammonium sulphate and potassium sulphate used separately and in combination are given. The average performance of the super. 6 cwt. and potassium sulphate 1 cwt. in conjunction presents a very striking figure. From the average percentage increase of 133 per cent. given by that combination there is a drop to the complete manure which gave an increase of 123 per cent. and from that again to the 110 per cent. increase from super. and ammonia. From these results there can be no doubt as to which of the mixtures tried is the most suitable for Warragul conditions.

TABLE I.—MANURIAL TRIALS, WARRAGUL.

Manures per acre.	Yield* 1930-31.	Increase over No Manure.	Average Yield* 5 years.	Percentage Increase—5 years' Average.
	T. C. Q.	T. C. Q.	T. C. Q.	%
Super. 3 cwt. ..	3 17 2	1 10 0	6 17 0	78
Super. 6 cwt. ..	4 15 0	2 7 2	7 17 3	104
Super. 9 cwt. ..	4 5 0	1 17 2	7 14 1	100
Super. 6 cwt., Pot. Sulph. 1 cwt. ..	5 15 0	3 7 2	9 0 1	133
No Manure	2 7 2	..	3 17 1	..
Super. 6 cwt., Ammon. Sulph. 1 cwt. ..	4 17 2	2 10 0	8 2 3	110
Super. 6 cwt., Ammon. Sulph. 1 cwt., Pot. Sulph. 1 cwt. ..	5 12 2	3 5 0	8 12 3	123
Market Garden Manure 6 cwt.	4 2 2	1 15 0	..	..
Basic Phosphate 6 cwt.	3 12 2	1 5 0	..	..

* Marketable tubers only.

Romsey.

During the three years in which trials have been conducted at Romsey there have been comparatively small differences between the results obtained from the various manurial treatments. The Romsey plots are conducted by the Department of Agriculture on the farm of Messrs. Spring Brothers on a red volcanic soil. The returns for the season 1930-31

and the average yields for three years are shown in Table II. In the season just passed the greatest increase over no manure was obtained on the plots treated with 3 cwt. super. alone and 3 cwt. super. plus 1 cwt. ammonium sulphate. In each case the increase amounted to 27 per cent. only. Why the Romsey soil should not respond to manures as readily as similar soils in other parts of the State is not obvious. This, however, can be said—that none of the three seasons during which this work has been in progress at Romsey has been favorable to the growth of heavy crops. These trials will be continued for some time yet, when more striking differences may be obtained.

TABLE II.—MANURIAL TRIALS, ROMSEY.

Manures per acre.	Yield* 1930–31.	Increase over No Manure.	Average Yield* 3 years.	Percentage increase—3 years' Average.
	T. C. Q.	T. C. Q.	T. C. Q.	%
2 cwt. Super. ..	6 16 0	0 2 0	4 8 1	14
3 cwt. Super. ..	8 11 2	1 17 2	5 0 1	30
4 cwt. Super. ..	7 3 0	0 9 0	4 9 0	15
No Manure	6 14 0	.. ..	3 17 0	..
3 cwt. Super., 1 cwt. Sul. Am.	8 11 2	1 17 2	4 19 3	29
3 cwt. Super., 1 cwt. each P.S. and A.S. ..	8 0 0	1 6 0	5 13 1	18†
3 cwt. Market Garden Manure	8 8 0	1 14 0	4 14 0	22
3 cwt. Basic Super. ..	7 17 0	1 3 0	4 10 1	16

* Marketable tubers only. † Two years only.

The three years' figures show greater differences than do those for last season only. While these differences are not comparable to those obtained from other potato districts they show a constant appreciation in weight from each of the various manures. The 3 cwt. super. dressing has given the greatest increase over the three years, the average increase over that period being 30 per cent., while the addition of 1 cwt. ammonium sulphate made practically no difference. On analysis the Romsey soil appears to be practically identical with that of Wheatsheaf, near Daylesford. Its rainfall, too, is practically the same. Yet, at Wheatsheaf, a very decided result in favour of 3 cwt. super. and 1 cwt. ammonium sulphate is shown over the same three-year period, viz., 78 per cent. average increase.

It is interesting to compare the Romsey and Wheatsheaf tables, because of the great similarity of their soils and climates and the great dissimilarity in their response to manuring.

Wheatsheaf.

The Wheatsheaf results are the more interesting because of the experience at Romsey and the remarks made in that report. As stated before, the returns here are very decided in their differences. The manurial treatment which shows the most marked benefit at Wheatsheaf is the dressing of 3 cwt. super. and 1 cwt. ammonium sulphate per acre. During the past season this combination gave an increase of 80 per cent. over the unmanured plot, yielding 9 tons per acre as against 4 tons 19 cwt. 2 qr. from the no manure. The 1930-31 yields and the average returns for three years are shown in Table III.

TABLE III.—MANURIAL TRIALS, WHEATSHEAF.

Manures per acre.	Yield* 1930–31.	Increase over No Manure.	Average Yield* 3 years.	Percentage increase—3 years' Average.
	T. C. Q.	T. C. Q.	T. C. Q.	%
2 cwt. Super. ..	6 2 0	1 2 2	3 10 1	38
3 cwt. Super. ..	6 4 2	1 5 0	3 16 0	50
4 cwt. Super. ..	7 12 1	2 12 3	4 0 3	60
No Manure	4 19 2	.. ..	2 10 2	..
3 cwt. Super., 1 cwt. Sul. Am.	9 0 0	4 0 2	4 9 2	78
3 cwt. Super., 1 cwt. each P.S. and A.S. ..	7 12 1	2 12 3	5 3 2	43†
3 cwt. Market Garden Manure	7 12 1	2 12 3	3 18 3	56
3 cwt. Basic Super. ..	7 12 1	2 12 3	3 17 0	52

* Marketable tubers only. † Two years only.

Remarkable evenness in yield was shown in the crops produced by 4 cwt. super., complete manure, market garden manure, and the basic phosphate respectively. The super. and potash mixture has not been included in the trials at Wheatsheaf for the past three years, as it was proved a definite failure previously. Over the three years' period the manurial combination that showed to the greatest advantage was the " 3 and 1 " dressing, which gave the material increase of 78 per cent.

The Wheatsheaf plots are conducted on heavy red volcanic loam on the property of Mr. Jas. Gooch.

Musk.

Very irregular results were obtained from the manurial trials at Musk during the past season. In fact, two of the super. dressings show an actual decrease as compared with the unmanured plots. Such erratic fluctuations are by no means infrequent in manurial trials, though they are not easily explained. They

might be due to such causes as seed variation, soil peculiarity, or accidental damage to those sections of the plots, though, of course, care is taken to eliminate, as far as possible, any error which might arise from unequally influencing factors. The results of the plots, which are situated on a light volcanic soil on the farm of Mr. E. Bull, are shown in Table IV.

TABLE IV.—MANURIAL TRIALS, MUSK.

Manures per acre.	Yield* 1930–31.	Increase over No Manure.	Average Yield* 3 years.	Percentage increase—3 years' Average.
	T. C. Q.	T. C. Q.	T. C. Q.	%
2 cwt. Super. ..	4 15 3	Nil	4 0 2	8
3 cwt. Super. ..	5 18 0	Nil	4 9 1	20
4 cwt. Super. ..	6 6 0	0 3 0	4 13 1	25
No Manure	6 3 0	..	3 14 1	..
3 cwt. Super., 1 cwt. Sul. Am.	8 3 1	2 0 1	5 14 2	54
3 cwt. Super., 1 cwt. each P.S. and A.S. ..	6 14 0	0 11 0	5 18 1	25†
3 cwt. Market Garden Manure	6 14 0	0 11 0	4 15 1	28
3 cwt. Basic Super. ..	7 7 1	1 4 1	4 11 3	22

* Marketable tubers only. † Two years only.

The average yields for the past three years show very definitely in favour of the "3 and 1" mixture. The average increase from that dressing over the unmanured plot for the period stated amounts to 54 per cent. It would seem to be fairly definitely established that the "3 and 1" dressing is the best and most profitable manure so far tested on the volcanic soils in the central highlands of Victoria. During coming seasons an attempt will be made to investigate whether increasing or decreasing the amount of nitrogen given would be beneficial. There has been a vast increase in the use of manures for potato-growing since these trials were initiated by the Department, and abundant evidence has been gained to show that judicious manuring is highly profitable. Unfortunately, because of the limited staff, it has not been possible to compute the residual effect of these manures.

Trentham East.

Results of manurial trials at Trentham East are on much the same lines as those obtained in other districts with volcanic soils. Detailed yields for 1930-31 and average returns for the past four years are shown in Table V.

TABLE V.—MANURIAL TRIALS, TRENTHAM EAST.

Manures per acre.	Yield* 1930–31.	Increase over No Manure.	Average Yield* 4 years.	Percentage increase—4 years' Average.
	T. C. Q.	T. C. Q.	T. C. Q.	%
2 cwt. Super. ..	6 2 2	0 15 0	5 1 2	71
3 cwt. Super. ..	6 15 0	1 7 2	5 15 0	95
4 cwt. Super. ..	7 2 2	1 15 0	5 8 0	83
No Manure	5 7 2	..	2 19 0	..
3 cwt. Super., 1 cwt. Sul. Am.	8 15 0	3 7 2	6 3 3	108
3 cwt. Super., 1 cwt. each P.S. and A.S. ..	7 2 2	1 15 0	5 9 0	84
3 cwt. Market Garden Manure	6 10 0	1 2 2	4 9 1	50
3 cwt. Basic Super. ..	6 0 0	0 12 2	4 9 2	50

* Marketable tubers only.

The Trentham plots are conducted on red volcanic loam on the farm of Messrs. O'Brien Bros. Four years' figures are now available, and these again very conclusively point to the higher efficiency of the 3 cwt. super. and 1 cwt. ammonium sulphate per acre as compared with other forms of manuring. The average increase for the four years 1927-28 to 1930-31 inclusive from the "3 and 1" mixture was no less than 108 per cent., the next best being the dressing of 3 cwt. of super. alone.

The depressing effect of potash is very marked on these plots, the yield from the dressing containing potash being more than 20 per cent. less than from the super. and ammonia combination.

Tobacco Growing

VI.—Bulking Down

By W. J. B. McDonald, B.Agr.Sc., Assistant Inspector of Agriculture; and G. E. Coghlan, Tobacco Field Officer.

The first Article of this Series, which appeared in the August issue of the Journal, dealt with the soil and climatic conditions most suitable for Tobacco growing and the preparation of Seed beds. Subsequent Articles in the September, October, November and December, issues describe the methods of transplanting the seedlings, the work involved in the care of crops, the construction of flue curing barns, and in the selection of seed, harvesting, and curing.

AFTER curing, tobacco is stored or bulked in heaps of varying sizes. A suitable stack is one about 4 feet wide and of any convenient length and height. This operation, technically known as "Bulking Down," plays a definite part in the production of quality tobacco.

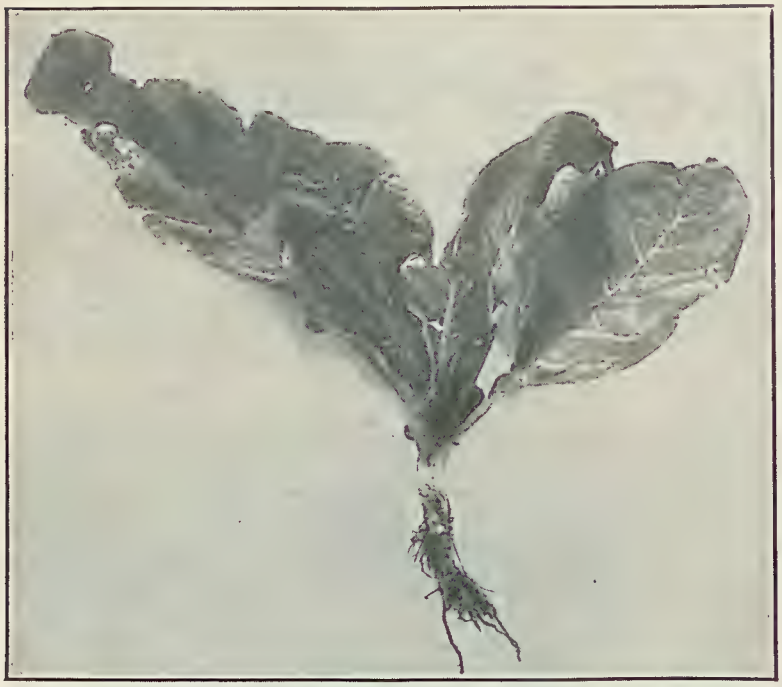
In a previous article it was pointed out that the curing process is essentially concerned with the activities of the living cell. During the bulking down period a mild fermentation, which may be described as the first step in the "ageing" of tobacco, takes place. This is concerned with the activities of various lower organisms, and results in definite chemical changes within the leaf tissue.

Tobacco plant showing collapse of leaves and stunted appearance due to attack by Stem Grub (see Seasonal Notes.)

The nature of the fermentation taking place depends on the condition of storage, and it therefore becomes essential that conditions should be such that the resultant fermentation is favorable to the development of the most pleasant aroma.

Tobacco bulked in the right condition undergoes a definite improvement in quality and colour, although bulking down will not overcome curing defects. Improvement in colour is most obvious in leaf which has been cured with traces of green still showing. The development of aroma, during ageing, may be compared with the "bouquet" which proper "ageing" bestows on wines.

Having completed the drying of the mid-ribs, it will be found that the leaf is much too brittle to handle. This difficulty is overcome by allowing it to re-absorb a certain amount of moisture; this has the effect of restoring toughness and pliability to the web of the leaf. The greater the amount of moisture absorbed the



Tobacco plant showing enlarged and malformed heart due to attack by Stem Grub.

more pliable and limp the leaf becomes. Should weather conditions at the completion of curing be moist or damp the leaf naturally will absorb sufficient moisture from the atmosphere to bring it into a satisfactory "condition." Under dry conditions it will be necessary to close the barn and induce a moist atmosphere by means of steam. If a jet of steam be injected into the barn great care must be taken to regulate the amount liberated, as any excess results in a rapid discoloration of bright leaf and a consequent depreciation in value. A safer method consists of re-heating the flues and hanging wet bags over them or re-introducing the pans of boiling water as previously described in the curing process. The amount of firing required for this purpose is just enough to keep the flues sufficiently hot to evaporate the water applied.

Leaf may be safely bulked down or stored with a 10 to 12 per cent. moisture content. This can be roughly determined by handling the leaf. Various tests are applied. The leaf, when crushed between the hands should crackle without breaking, and rapidly regain its normal position when released. If too damp, a condition which must be religiously avoided, there will be no crackling, and the leaf will be inclined to remain in a limp state. A further test consists of doubling the mid-rib between the finger and thumb. Even when "conditioned" this should crack two-thirds of the way up from the tip.

A leaf containing too much moisture will show signs of bruising when rubbed between the thumb and forefinger. In actual practice it will be found that the lower tiers of leaves reach a satisfactory "condition" before the upper ones. As the leaves acquire the necessary degree of moisture they should be removed from the barn and stacked into the bulk; at the same time the upper tiers should be moved progressively downwards.

The actual bulk should not be built in contact with, or too close to the earth, so as to guard against moisture being too readily absorbed, thus creating conditions favorable to the development of various moulds. An air space of at least eighteen inches between the bottom of the bulk and ground level is recommended. Where a good hardwood floor is available the leaf may be placed immediately on it, the first layer consisting of any trashy material that may be on hand. Where such a floor is not available, a staging or platform of any convenient dry material should be constructed. Dry poles serve quite well for the purpose. These should be covered with straw or some form of matter to act as a buffer between the first layer of leaf and the hard edges of the poles or battens. Bagging may be placed over the platform, but should not trail on to the ground.

There is some diversity of opinion as to the best method of bulking down. Many growers bulk their leaf on the stick. Should it be necessary to rebuild the bulk at any time, or should the leaf become sufficiently moist to require rehanging, a great saving of time and labour is effected by the use of this method, as the rehandling of the leaf is greatly facilitated. On the other hand, should the grower be quite confident that his "cure" has been satisfactory, and that his leaf, when bulked, is in the right condition, a more rapid and even fermentation

should occur when the leaf is bulked "off the stick." By so doing the stack becomes much more air-tight and compact—conditions favorable to the most satisfactory class of fermentation.

Should the leaf be bulked down in an excessively moist condition, the temperature of the bulk rises rapidly, followed by an infestation of mould. If immediate steps to rectify this condition be not taken, general decay sets in. The bulk should be inspected at least once a week for signs that would indicate any of the above troubles. This is usually done by lifting a section of the heap and inserting the hand to detect any signs of over-heating. Should such inspections indicate a rapid rise of temperature it will be necessary to rebuild the bulk.

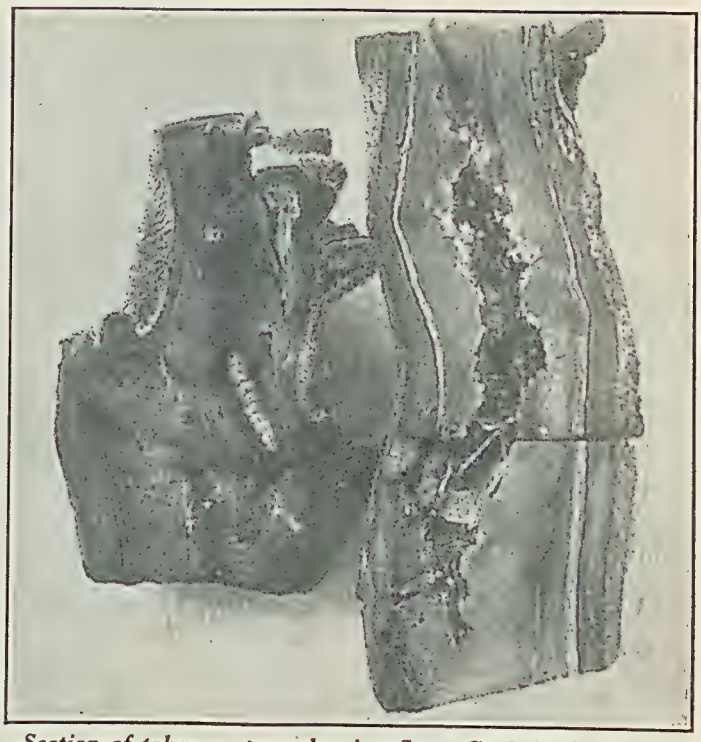
In the rebuilding every bundle of leaf should be shaken loose and inspected for mould; any mouldy leaf should be put aside and later dried out. This leaf must never be returned to the main bulk. As far as possible the respective positions of the inside and outside leaf in the orignal bulk should be reversed in the new one.

In building the bulk, the butts of the leaf are always directed toward the outside. The first row of leaf is placed down with the butts of the leaf flush with the outside of the platform. The second row is placed with the butts lapping about one-third of the first layer of leaf put down. The other side of the heap is built similarly and a binding row placed up the middle. This method of procedure is followed until the bulk reaches the desired height. If during the course of construction any depressions occur in the heap, the top is kept level by building in an extra layer of leaf. The ends of the bulk should be bound with an occasional cross layer. When completed the bulk should be covered as a protection from dust and light. As hessian is required later in the season for baling the leaf, it is a wise plan to purchase it early and utilize it first as a bulk cover.

If put down in good condition, leaf can remain in the bulk for an indefinite period, its quality and uniformity improving with storage.

SEASONAL NOTES.

Among the many insect pests that are damaging the tobacco crop, one of the worst and yet least familiar to the grower is that known as the stem grub. This is the larvae of a moth closely allied to and similar in appearance to the potato moth. Infection may take place either in the seed-bed or in the field. Probably the greatest degree of infection takes place in the seed-bed when the grub bores its way into the stem just below the heart and feeds on the internal tissue of the stalk without showing any very obvious signs of its presence. The experienced grower, however, can detect its invasion by the soft and swollen nature of the stalk in the heart region and by some malformation of the basal portions of the leaves. Sometimes the presence of the grub causes a temporary stimulation of plant growth inevitably followed by a total collapse of the aerial portion of the plant.



Section of tobacco stem showing Stem Grub (left) and pupa (right), also damage done to interior of main stem (enlarged).

Infected plants detected when pulling should be destroyed. Where the presence of the grub is suspected in plants already established in the field the main stalk should be cut off below the area of infection and one of the resultant suckers trained into the main stem. This operation should not be unduly delayed, otherwise the sucker will not have sufficient time to mature a satisfactory crop of leaf.

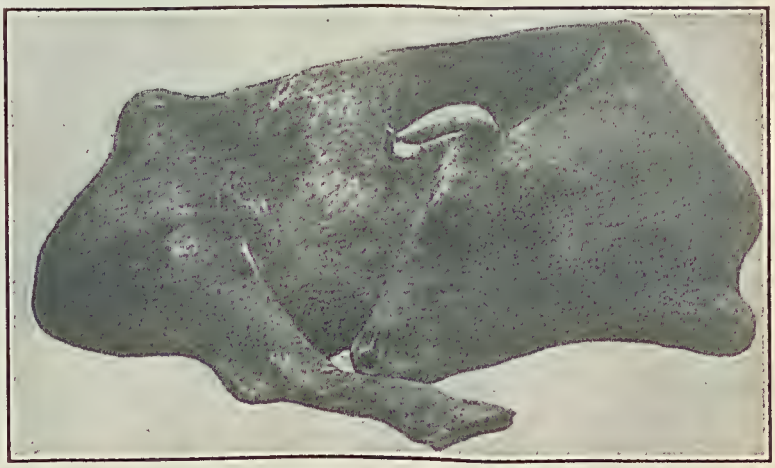
Milk Fever

Symptoms and Treatment

By R. N. Johnstone, B.V.Sc., Senior Veterinary Officer

MILK fever is a disease which affects milking cows at or about the time of parturition, and is characterized by a condition of general paralysis and an almost complete loss of consciousness. Contrary to what one might expect, the temperature is several degrees below normal during the attack.

The disease was first recorded by a German veterinary surgeon in 1808. Milk fever seems to be almost exclusively confined to cattle, although several authorities assert that it occurs rarely in goats, sheep, and swine. Its spread appears to have been coincident with better feeding and higher milk production by individual cows in the various breeds. Cows which are heavy milk producers are particularly liable to attack. The great majority of cases occur in cows over five and under twelve years of age. Cows under six years of age are very rarely attacked. Many more case of milk fever occur after easy births than after difficult ones. Thus of 129 cases, 120 of the births were normal and easy. Well-nourished cows, especially those which have been dry for several weeks and have been fed intensively before calving, are very susceptible to the disease. Some cows appear to have an individual predisposition to milk fever, and suffer attacks after each calving for several years.

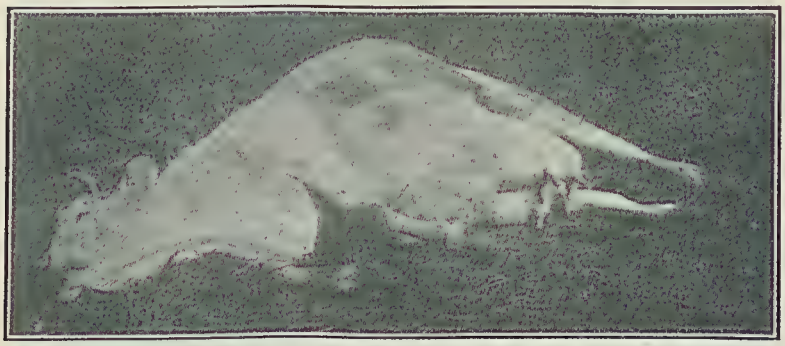


Typical attitude of cow with milk fever.

Most cases occur within the first three days after calving. Some, however, happen later, and a very few during or before parturition, but never before milk secretion is established.

Symptoms.

Generally, from the first to the third day after calving, the appetite fails without any visible cause; at the same time, the animal exhibits a peculiar restlessness, looking about nervously and stamping its hind feet. Exceptional ones show intense excitement and twitching of the muscles. Some degree of weakness soon becomes noticeable; the animal staggers, trembles, spreads out the forefeet, and finally falls to the ground. Several attempts to rise may be made, but gradually the animal becomes semi-conscious. At this stage the cow lies half-way over on her side, the feet are drawn under the body and the head is turned sideways and rests on the shoulder on the upper side; if the head is straightened out and then let go, it immediately falls back helplessly into its previous position. Occasionally the animal lies on its side with its head stretched out and the legs extended. All muscles seem to be relaxed but not paralysed, since the animal at times turns over or gets on her knees and creeps forward. Usually the eyes remain half closed, are dull in appearance, with the surface dry, but at times they are completely closed and the animal appears asleep. The pupils are dilated, the mouth is half open, the tongue protrudes, and its upper surface is dry while a copious flow of saliva is present and visible.



A severe case—cow completely prostrated.

While in this condition the animal cannot swallow. The respirations are deep and slow. The udder is always loose and soft, and secretes little or no milk.

As a rule, the illness develops quite rapidly, usually within an hour, and in the absence of treatment remains unchanged for about a day. In favorable cases recovery occurs just as rapidly. The patient opens her eyes, looks about with uplifted head, moves her tongue, swallows, her temperature becomes normal, and finally she gets up and takes food. Complete recovery can occur within a quarter of an hour, even in severe cases where death was to be feared every moment. In other cases the animal remains weak for several days. In unfavorable cases death may occur so quietly as to be almost unnoticed or the animal may become restless and finally die in convulsions. Occasional cases of recovery are followed one or two days later by pneumonia as the result of inhalation of saliva or the administration of drenches while the animal is semi-conscious.

The symptoms are so characteristic and are so definitely associated with calving and the formation of milk that diagnosis is comparatively easy. Before the air treatment was employed an average of 60 to 70 per cent. of cases ended fatally; to-day the mortality is less than 1 per cent. Some apparently severe cases recover rapidly, while other mild cases are more difficult to treat and may even die despite treatment.

Treatment.

It is essential that treatment should be commenced as soon as possible. In every case, if at all possible, the animal should be treated by a qualified veterinary surgeon who, because of his training, has a more intimate knowledge of the use of antiseptics; he has also a variety of treatments not available to the layman. If qualified assistance is not obtainable, treatment should not be delayed. First of all, the animal should be provided with a sheltered airy place, well bedded, and placed lying on her breast-bone, slightly inclined to the left side with her feet tucked under her. She may be supported by bags of chaff or bundles of straw if necessary.

The administration of medicine by the mouth should be avoided. In its semi-conscious state the animal cannot swallow, and drenches almost invariably enter the lungs and cause death by pneumonia. If bloat occurs, the gas should be removed by means of a stomach tube or trochar and cannula.

In 1897, Schmidt, a Danish veterinarian, while carrying out a microscopic examination of the milk of several cows affected with milk fever, discovered what he believed to be broken up cells in the milk, and concluded that some ferment or poison due to an organism within the udder was responsible for the destruction of the cells which line the milk ducts. Having formed this conclusion, he immediately set himself to devise a means for the destruction of these organisms and, choosing iodine of potassium, which was then believed to possess antiseptic properties, he injected a solution of the drug into the udder in a series of milk fever cases. This treatment met with remarkable success, reduced the rate of mortality from 60 to 70 per cent. to 15 per cent., and revolutionized the treatment of the disease.

As a matter of fact, Schmidt made a false observation; had he examined the colostrum or first milk of healthy cows he would have found that what he mistook for broken up cells were quite normal, and could be found in the milk of quite healthy animals. It is extraordinarily fortunate that he did not do so, for through his mistake he discovered a treatment, the curative effects of which were little short of miraculous.

Later on the treatment was modified by the injection of air, together with the drug, and finally Anderson and others found that the drug was quite unnecessary, and simple inflation with air gave even better results. That method has now become the general

practice in treating milk fever, and by its aid the mortality has been reduced to less than 1 per cent.

Great care must be exercised during inflation. If strict antiseptic precautions are neglected, the introduction of dirt into the udder will cause mastitis, which may render the animal useless except for beef. The simplest form of apparatus consists of a hard rubber bulb connected with a hollow metal cylinder containing cotton-wool and an udder catheter or milking tube. It is sterilized by boiling in water and rinsing out with a 2 per cent. solution of lysol.

Another case of complete prostration with intense tetanic spasms.

First remove all milk from the quarters and then thoroughly wash the udder and surrounding parts with warm water and soap. A clean cloth soaked in a 2 per cent. solution of lysol or some other suitable disinfectant is then placed under and in front of the udder to prevent the instruments coming into contact with the ground, dirty straw, or other dirt. The teats and surrounding parts are then thoroughly rinsed in a solution of lysol. The catheter or milking tube is now introduced into the teat canal and held in position with the thumb and finger while sufficient air is introduced to cause a plainly visible, tense, elastic stretching of the udder. The lower quarters should be inflated first and then the upper ones. After removal from each teat and before insertion into the next, the catheter should be placed in an antiseptic solution in order to keep it thoroughly sterile. After inflation the udder should be gently massaged to distribute the air through the milk ducts. As a rule, the animal recovers quickly after inflation; if, however, she does not get up in six hours the treatment should be repeated as often as necessary. If possible, avoid inflation of cows which have had mastitis and have one or more quarters affected. In such cases a veterinary surgeon, if available, may use other treatments such as intravenous injections.

Cause of the Disease.

Many theories as to the cause of milk fever have been held during the last 100 years, and each in its turn has been disproved. Recent advances in biological chemistry, however, have enabled workers to demonstrate by the analysis of the blood that in cases of milk fever the calcium (lime) content of the blood is from 20 to 60 per cent. below normal. This theory was first postulated by J. Russell Greig, M.R.C.V.S., Director of the Animal Diseases Research Institute, Moredun, Edinburgh, in March, 1925, and later proved ot be correct, first by Little and Wright in America, and subsequently by many other investigators. Later investigations have disclosed a deficiency in phosphorus also, and it would now appear as the result of these investigations that the essential cause of milk fever is an acute blood calcium-phosphate deficiency. There is no difference between the blood calcium-phosphate values of normal parturient cows and those in non-parturient cows and bullocks. The onset of milk secretion is accompanied by a fall in blood calcium-phosphate because of the quantity secreted by the udder in the milk. Cows with a reserve supply can rapidly replace the loss, but others cannot do so, and an attack of milk fever is the result. Inflation of the udder causes a pronounced rise in the blood calcium by preventing further secretion and, possibly, by driving back to the blood stream any calcium present in the udder.

These discoveries have led to a new method of treatment, which consists in the injection of various salts of calcium and phosphorous into the blood stream. The treatment is very

(*Continued on page* 34.)

Strawberry Culture

Fungus Diseases and Insect Pests

By D. B. Adam, B.Agr.Sc., Plant Pathologist, and R. T. M. Pescott, M.Agr.Sc., Entomologist.

THE fungus diseases affecting strawberries, fortunately, are of small concern to the grower. From his viewpoint they may be considered under three headings—

(1) Leaf spot disease;

(2) Plant failure associated with root disease; and

(3) Fruit rots—market diseases.

The first group is of limited importance; the second difficult to deal with; and the third troublesome only with careless management or when unfavorable seasonal conditions occur.

Strawberry Leaf Spot.

The symptoms of strawberry leaf spot are to be found on the leaf and the fruit stalks. On the leaf, they appear as spots, varying from a reddish fleck to definite round areas having whitish centres with purple-red edges. On the fruit stalk they form elongate patches of white dead tissue.

The infection of the fruit stalk, especially when it takes place early in the season, hinders the development of the berries, which remain small and dry. Probably it is this aspect of the disease that is the most serious one under local conditions, and growers are urged to examine plants closely for these symptoms.

Leaf spots may be caused by a number of fungi of which *Mycosphaerella fragariae* (Tul.) Lindau probably is the most common. Although these diseases are seldom serious under local conditions, the loss actually caused may warrant the small cost of control. Results from experimental work in America, in parts of which this disease is of serious economic importance, have shown that effective control is secured by spraying plants with Bordeaux mixture —firstly, when they are just beginning to grow in spring; secondly, just before the plants blossom; and, thirdly, immediately after blooming.

Bordeaux mixture for this purpose consists of bluestone ($CuSO_4$), 4 lb.; quicklime, 4 lb.; and water, 50 gallons.

The bluestone is dissolved separately in a small quantity of hot water, and then made up to 25 gallons with additional water. The solution must be kept in a wooden or enamelled vessel, since the bluestone attacks ordinary iron containers, and brings into solution substances harmful to plant growth. The quicklime, which must be fresh and in lumps, is slaked separately in a small quantity of water. After slaking, the milky solution is made up to 25 gallons, and then, either poured into the bluestone solution or together with the bluestone solution into a third vessel, when it is ready for use.

This solution should be a rich sky blue, and free from greenness.

Plant Failure.

In recent years growers have complained about the death of individual plants. Most frequently these deaths take place irregularly over the whole cropped area, although on occasions plants die out in patches. These deaths, however, are not sudden, the plant usually starts off well enough in early spring, but when the crop is half formed, growth stops suddenly and the outer leaves and berries wither. Later in the season, if there is plenty of moisture, fresh young leaves are produced, but these are small, have yellow edges, and generally appear unthrifty. Although plants may hold on in this unthrifty stage for some time they never again produce a crop of berries.

A number of different fungi, including *Pythium* sp., *Rhizoctonia* sp., and *Botrytis* sp. have beenn obtained from the roots and crown of diseased plants. At this stage of our investigations, however, we are inclined to think that some soil deficiency may be playing an important part in bringing about this diseased

condition, and that these fungi, as causes of the disease, are of secondary importance. The feature common to the heavy wet clay soils near Melbourne, and the red, loamy soils of the Mornington peninsula, where the bulk of the Victorian strawberries are grown, is a low-lime content and consequent acidity.

However, this problem must be approached with a good deal of caution, as it is only in exceptional conditions that the addition of lime to the soil for strawberries is beneficial; indeed, there is a good deal of evidence to indicate that the strawberry is partial to acid soils. On the other hand, there is the evidence that a plant failure disease in Scotland is, as with us, associated with soil conditions where lime and humus are deficient, and acidity excessive.

Therefore, where a grower has been troubled with this root failure disease, and he wishes to grow strawberries again on the same land, the addition of a good lime dressing, say, 2 tons per acre, at least one season prior to again setting out strawberries is recommended. The interval should be devoted to the growth of some bulky green manurial crop such as rye or barley and vetches, which is ploughed in late in the autumn prior to the spring in which the strawberries are set out.

Fruit Rots.

The close proximity of practically all local growers to their market and the rapidity of transport thereto, help to explain why very little loss from strawberry fruit rots is sustained in this State. Of fungi capable of causing fruit rots, two, viz., *Botrytis* sp. and *Rhizopus nigricans* Ehr. are the most common. The former fungus may attack berries in the field, and cause a firm rot, the berry after a few days of dry weather becoming hard and leathery. This fungus also attacks fruit in transit to market during cool weather. The latter fungus, which always causes a soft wet rot, is the pinhead "whiskered" fungus prominently present that appears to cause the berries to melt. This latter disease is practically confined to the hottest periods of the year and to fruit that has been delayed in reaching the consumer.

Where loss from fruit rot is to be anticipated, whether by reason of distance from the market or from the condition of the fruit, certain handling precautions should be taken. Firstly, extreme care should be exercised in picking the fruit; not only should any suspicious or overripe berries be omitted, but the greatest care should be taken in handling and the avoidance of injury to the sound fruit. This precaution is necessary, because any break in the skin of a sound berry will permit and hasten the development of these rotting fungi which are to be found everywhere. Secondly, picking should be confined to the coolest times of the day, and berries, even after picking, should be kept as cool as possible. This precaution is very important. Thirdly, though washing should be avoided if possible, if it is necessary to do so, berries should be packed immediately while still wet rather than be dried off.

INSECT PESTS AND THEIR CONTROL.

The Strawberry Beetle.

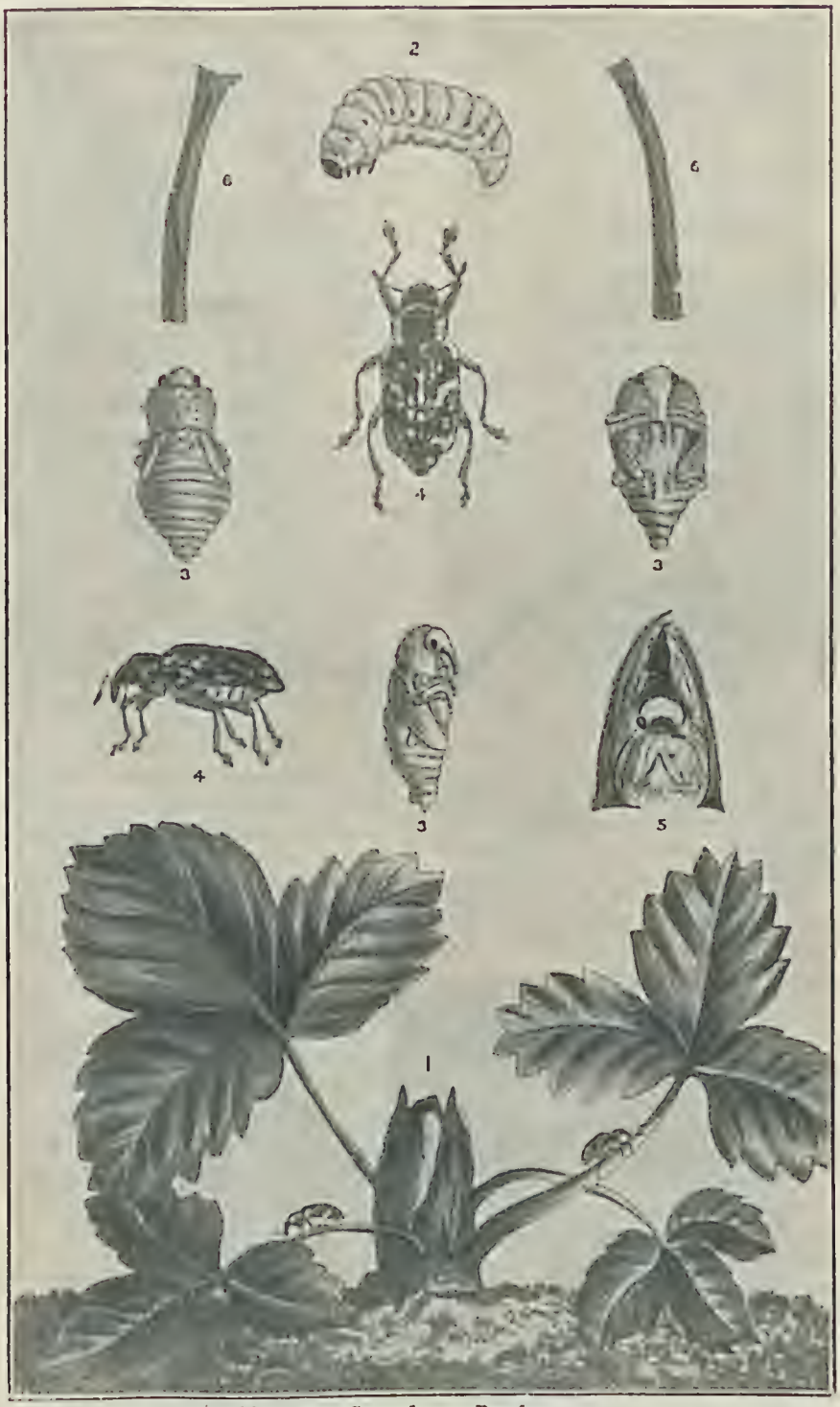
Of all the insect pests attacking the strawberry, the Strawberry Beetle or Weevil (*Rhinaria perdix*) is probably the most destructive. It is not confined to the strawberry, being a frequent pest to the raspberry-grower also.

The perfect insect is about ¼ inch in length, drab in colour, with black and white markings, and possesses the long snout characteristic of members of the weevil family. The beetles generally make their first appearance in November, although this is dependent largely on climatic conditions. They are plentiful in December, and are found until the early part of February. This beetle is unlike many of the weevils in that it possesses wings, and, doubtless, can fly from one orchard to another.

The eggs are deposited by the female in the crown of the plant generally at the beginning of December, and hatch out about six weeks later. They first attack the crowns, often hollowing out a large hole, and causing the crown to decay or rot away. Both the flower and the leaf stalk may be destroyed by the insects tunnelling in them. The pupae pass the winter in the soil close to the plants.

Owing to its appearance so late in the season and the presence, on the plants, of ripe fruit, it is difficult to attack the larvae with a spray. Poisoned baits worked around the plants will prove very effective, the larvae being lured to the baits. These baits can be prepared as follows:—

Calcium arsenate ..	1 lb.
Sugar or molasses ..	1 lb.
Bran	9 lb.



The Strawberry Beetle.

1. Strawberry plant with beetles on leaf stalks; 2. Larva of beetle, magnified; 3. Pupae of beetle, upper, under, and side view, magnified; 4. Perfect beetle, magnified; 5. Section of crown of plant showing larva attacking same, natural size; 6. Portions of leaf stalks showing where they have been tunnelled by the insects, natural size.

This is mixed with sufficient water to make a wet mash. Small portions of this, about the size of a walnut, are placed in the shade around the strawberry plants.

Early spring working with the cultivator will dislodge many of the pupae, and expose them to the attacks of birds.

Tomato Weevil.

The Tomato Weevil (*Desiantha nociva*) is a comparatively new pest, and affords an example of a native insect forsaking its natural food and attacking cultivated crops.

The larva is of a light pea-green colour, measuring about ¼ inch in length. In the day time, it is usually found in the soil a few inches below the surface. When about to pupate it constructs a cocoon made of soil, where it remains for a couple of months until it emerges as the perfect beetle. The beetle, which measures about ¼ inch in length, varies in colour from light grey to dark brown, and possesses the snout characteristic of weevils. Some specimens have a V-shaped mark on the wing cases. It is quite as destructive as the larva, and, like it, goes down into the soil in the day time, coming up to feed at night. It is a prolific breeder, and is found at all times of the year.

For the control of this pest all weeds, especially marshmallows, on land adjoining the strawberry garden should be destroyed. Poison baits as in the case of the strawberry beetle should also be used. If the crops are not ripening, the plants could be sprayed with arsenate of lead, 1 in 25.

Cockchafer Grubs.

The Cockchafer grub (*Heteronyx* sp. and *Haplonyx* sp.) at present is a very serious pest to the strawberry-grower, and mainly on account of its method of attack on the strawberry plant is a very difficult pest to deal with.

The adult beetle is about ¾ inch in length, and in colour is largely dull brown. The thorax, which is fairly small, is coloured black. The adult beetles usually are found about dusk swarming around gum trees. The eggs are laid on the surface of the soil or on the crown of the plant, and hatch out in about three weeks in suitable weather. The larvae, on hatching from the eggs, commence to burrow into the soil, feeding on the roots immediately under the crown of the plant. As they grow large they cause extensive damage to the root system of the strawberry, finally causing the death of the plant. The pupae are found in the soil usually about September.

The larvae do not come above the ground to feed as with most cockchafers, and so cannot be attacked with poison sprays, such as arsenate of lead. Cultivation in the spring will expose numbers of the larvae, which are eagerly sought after by insectivorous birds.

Soil fumigation with carbon bisulphide and paradichlor-benzine is recommended in some countries, and experiments with these fumigants are now being carried out. Results of this work will be published later.

The Take-all Grub.

A severe local outbreak of the Take-all grub (*Oncopera intricata*) occurred this year in an orchard in the Dandenong Ranges, and was responsible for considerable damage.

The larva or grub, when fully grown, is about 2 inches in length, and about two-thirds the thickness of an ordinary lead pencil. It is then of a dark, dirty green colour, and each of the segments of the body is hairy and warty. Soon after becoming full fed, it ejects all its undigested food, and casts its skin and turns to the chrysalid stage. The larvae, when feeding, lie perfectly flat. Perfectly healthy grubs are never seen above dry ground during daylight—their maximum destruction occurs about midnight. The grubs first hatch in April, and do not form tunnels in the ground for some time. From the time the grubs are half grown till their final stage, each grub constructs only one tunnel. These tunnels vary in length, according to the softness of the ground—in soft ground they are seldom less than 12 inches in length. Where food is abundant the tunnels usually are lined with silk. The tunnels are usually at an angle for the first inch, but after that go straight down. For the mouth of each of the tunnels a sort of "silken door" is constructed of dried grass and excrement.

The perfect stage of this insect is a moth, usually measuring from 1½ inches to 2½ inches across the wings. In colour, they are of a dingy greyish brown, with the fore wing variegated with yellow and white. The first moths usually appear about January and the last in March.

A common impression held regarding the grub is that it feeds on the roots of the plants as well as the stems and foliage, but this is not so. In forming its tunnel, it burrows through the roots, but does no damage to

them. The main damage is done to the young shoots and foliage.

For control, poison bran baits, as recommended for the strawberry weevil, are very successful. Soil fumigation with carbon bisulphide possibly will prove efficient also.

Thrips.

These pests (*Thrips tabaci* and *Thrips imaginis*) frequently do considerable damage by sucking the juices from the young flower buds, causing them to drop with a total loss of crop. They also attack the young fruits, causing them to shrivel. A "thrippy" strawberry is quite common in some seasons.

Fortunately, severe outbreaks of thrips are uncommon, and depend to a large extent on weather conditions. A dry, hot spring and summer is very conducive to thrip activity.

Benzole emulsion is probably the most effective deterrent for thrips. This is used at a strength of 1 lb. of the emulsion in 5 gallons of water. It will not damage the tenderest foliage, and its effects will last for several days.

Nicotine sulphate or black leaf 40 also are excellent sprays.

Metallic Flea Beetle.

These insects (*Haltica pagana*), which assume epidemic form only in cycles, have the habit, when disturbed, of suddenly hopping from the plants being attacked. They are native insects usually found feeding on the weed, Sheeps' Burr. The perfect insects are dark-violet coloured, about ¼ inch in length, and may be distinguished by their exceedingly large hind legs, which furnish them with the power of jumping. The larvae live in the soil.

These beetles are easily kept in check by the use of arsenate of lead, 1 in 25. Poison baits, as for the strawberry weevil, are also recommended.

Light Brown Apple Moth.

This native insect (*Tortrix postvittana*) has recently turned its attention to the strawberry, particularly the crown of the plant. It is most in evidence in a dry season, when the larvae are often responsible for the total destruction of the crown. The larva is of a dirty, greyish green colour, rather more than ½ inch in length when fully grown. It is often mistaken for the Codling Moth, but is narrower, and never has the pink flush so common with the Codling grub.

Lead arsenate sprays forced into the crown of the plant whenever the infection arises will be the most effective control.

Other Pests.

Snails, slugs, and woodlice are commonly found by the strawberry-grower, but are easily controlled by the use of calcium arsenate poison baits, as recommended for the strawberry weevil.

Orchard and Garden Notes

By Edward E. Pescott, F.L.S.

The Flower Garden.

ONE very important work in summer is the conservation of soil moisture and keeping cool the roots of garden plants. Hence we cultivate the soil well, working the surface into a fine tilth, and maintaining it in that condition all through the season.

An equally important work, and perhaps a more valuable one, is the mulching of the garden beds. The material used for mulching is usually animal manure of some kind, but grass, straw, lawn clippings, or similar material will do just as well. The object of the mulch is not to feed the plants, so that the manure need not necessarily be of good quality. Any manure, no matter how old it is, may be used for the purpose. If possible, the soil should be well watered, and then cultivated before mulching.

Many summer flowering plants such as Cannas, Delphiniums, Agapanthus, Crinum, and others are now in full flower. These should be encouraged by water and mulching. Belladonna Lilies are also in full flower. These plants are all very suitable for garden culture under hard conditions, and they revel in sunny positions. Belladonna Lilies should be watered freely after the flowering is finished to induce a good foliage growth.

Sow now seeds of Sweet Pea, Carnation, Aquilegia, Wallflower, Mignonette, Pansy, Primula, Stock, and Iceland Poppy for winter flowers.

The Orchard.

The long period of time that necessarily elapses between the planting and the fruiting of apple trees is one of the factors which frequently deters people from planting. In a paper delivered last year at the American Pomological Society, Mr. W. S. Perrine, of Illinois, stated that to bring the young apple orchard into early bearing, the trees should be pruned as lightly as possible consistent with securing a strong, well balanced, open framework. Little winter pruning is done. During the first two or three summers, any strong growth of the limbs competing with what are called the "scaffold limbs" or what we would term the "main leaders," are tipped from time to time. This directs the main growth into the framework, making it stocky and vigorous.

The Belladonna Lily.

The result is that very little pruning is necessary in the dormant season, that is, in winter. Only a few strong growths may need lightly cutting back. After the second season, the summer tipping is very light, and only enough thinning is done to let an abundance of light into every part of the tree.

It is claimed that this method is conducive to fruit bud formation on young trees, to the production of a sturdy tree, and to early fruit bearing.

The Vegetable Garden.

Ample water and manure are needed for all crops; especially for Lettuce, Tomato, and plants of the Cucumber-Melon-Marrow family. Especially should water be given during a hot sunny day. French beans should be well watered after gathering the crop to induce another crop of blossom.

Sow seeds of Celery; and sow for early crops a few seeds of Cabbage, Turnip, Cauliflower, Brussels Sprouts, Carrot, and Parsnip.

Artificial Fertilizers Registered for 1932

ANALYSES AND UNIT VALUES.

By Will C. Robertson, Chemist.

THE Fertilizers Act, as administered by the Victorian Department of Agriculture, aims at assisting the producer by controlling the quality of the artificial fertilizers sold within the State.

The Act requires that, before any artificial fertilizer is offered for sale in Victoria, it must be registered at the office of the Director of Agriculture. Any person who sells an unregistered fertilizer is liable to a penalty of not less than £10 for a first offence, and of not less than £100 for any subsequent offence. No brand is registered unless the fertilizer it represents is of at least fair quality and commercial value; the farmer, therefore, should refuse to purchase any fertilizer unless some brand is affixed to it. Further, it is compulsory for the seller to see that every bag or parcel containing fertilizer exceeding 56 lb. in net weight bears a label setting out (*a*) the net weight in pounds; (*b*) the registered brand; (*c*) the name and address of the manufacturer or importer and the place of manufacture; (*d*) a chemical analysis guaranteeing the percentage of the three plant foods, viz.:—Nitrogen, phosphoric acid, and potash, and the respective forms in which each occurs in the fertilizer.

Invoice Certificate.

Upon the sale of any fertilizer, whether paid for at the time of sale or not, the vendor must, at the time of sale or before delivery of the fertilizer, or any part thereof, give to the purchaser an invoice certificate signed by the vendor or his agent stating (*a*) the name and place of business of the vendor; (*b*) the registered brand; (*c*) the quantity of the fertilizer comprised in the sale; and (*d*) a chemical analysis guaranteeing the quality of the fertilizer in a similar manner to that on the labels attached to each bag or parcel. Infringement of the requirements of the Act regarding labelling or the giving of invoice certificates renders the vendor liable to a penalty.

It is important that farmers should see that an invoice certificate (which is a guarantee as to quality) is received with each parcel of fertilizer purchased and, furthermore, the certificate should be carefully preserved until the following season.

Unit Values.

The Chemist of the Department of Agriculture, from the results of the analyses of the simple fertilizers set forth in the application for the registration of brands, computes unit values annually.

The unit value as so calculated is the commercial value of 1 per cent. of nitrogen, phosphoric acid, or potash in their respective forms in 1 ton of fertilizer. Unit values provide the farmer with a useful method of ascertaining the comparative values of various fertilizers or of various brands of one particular fertilizer.

It should be remembered that "unit values" are the commercial values based on average ruling prices for simple fertilizers, and are not

Co-operative Phosphate Company's works at Geelong.

agricultural values standardized by the Department of Agriculture. The composition and retail price of a fertilizer (within reasonable limits) are in the hands of the manufacturers and importers; it will thus be readily seen that it is they who actually control the unit values.

Calculating the Monetary Value of a Fertilizer.

To obtain the comparative value of any artificial fertilizer on the market, the buyer must have—

(*a*) the list of unit values for the year.
(*b*) the percentage composition of the fertilizer.

The unit values for each year are printed in this *Journal* for the month of January; except in a few isolated cases under (*b*), and if the information be required in these instances, application should be made for it to the Chemist of Agriculture.

The value of the fertilizer per ton may then be obtained by multiplying the percentage of each fertilizing ingredient by its respective unit value.

The following examples will serve to illustrate:—

DRIED BLOOD.

	Per cent.		Unit Value. s. d.		£ s. d.
Nitrogen as blood ..	12·00	×	18 4	=	11 0 0
Phosphoric Acid as Citrate Insoluble	·75	×	4 6	=	0 3 4
Potash taken as Chloride ..	·50	×	6 8	=	0 3 4
Calculated value per ton					11 6 8
Price asked per ton					9 10 0

In a case of this description the calculated value will enable the farmer to come to a quick decision because, when computed commercially, the price charged is found to be most reasonable.

BLOOD AND BONE.

	Per cent.		Unit Value. s. d.		£ s. d.
Nitrogen as Blood and Bone	5·33	×	18 4	=	4 17 8
Phosphoric Acid as Citrate Soluble	6·00	×	5 6	=	1 13 0
Phosphoric Acid as Citrate Insoluble	7·50	×	4 6	=	1 13 9
Calculated value per ton					8 4 5
Price asked per ton					7 17 0

This calculation is based upon the average analysis of the brands of blood and bone registered for the current season, and the price asked per ton is the average of the prices submitted with the registrations.

COMPLETE FERTILIZER.

	Per cent.		Unit Value. s. d.		£ s. d.
Nitrogen as ammonia ..	2·50	×	11 8	=	1 9 2
Phosphoric Acid as Water Soluble	14·87	×	4 6	=	3 7 0
Phosphoric Acid as Citrate Soluble	·36	×	4 0	=	0 1 5
Phosphoric Acid as Citrate Insoluble	·72	×	1 0	=	0 0 9
Potash as Sulphate ..	7·26	×	7 11	=	2 17 6
Calculated value per ton					7 15 10
Price asked per ton					9 0 0

At first glance it would appear from the figures that this fertilizer is of poor value. This is not so. The cost of admixture is not taken into consideration in calculating the price per ton, and the farmer will understand that the extra labour involved in mixing the ingredients, and the capital expenditure in the additional machinery necessary for their thorough incorporation is the reason for the difference between the calculated value and the price asked per ton.

BONEDUST.

It will be noticed that the list of unit values provides separate values for nitrogen and phosphoric acid as fine and coarse bone respectively. The Fertilizers Act provides that the mechanical condition of a bonedust shall be guaranteed, together with the percentages of nitrogen and phosphoric acid; in addition, bonedust is defined as a fertilizer consisting only of disintegrated bones, and containing at least 19 per cent. of phosphoric acid. The fine material must be at least 50 per cent. The reason for the latter stipulation is that the finer the degree of division, the greater the availability of the plant foods.

To calculate the value of a bonedust from the unit values, it is necessary in the first place to compute the percentages of phosphoric acid and nitrogen present as fine bone and coarse bone respectively. To do this, multiply the percentage of the fertilizing ingredient by the percentage of fine bone and divide by 100. This will give the percentage as fine bone, which, when subtracted from the total, will leave the percentage as coarse bone.

Take the case of a bonedust guaranteed to contain:—

	Per cent.
Nitrogen	4.00
Phosphoric acid	19.00
Fine bone	50.00
Coarse bone	50.00

Then 4 per cent. nitrogen × 50 (per cent. fine bone) divided by 100 equals 2 *per cent. nitrogen as fine bone,* and this substracted from the total nitrogen, viz.: 4 per cent. leaves 2 *per cent. nitrogen as coarse bone.*

Similarly 19 per cent. phosphoric acid × 50 (per cent. fine bone) divided by 100 equals 9.5 *per cent. phosphoric acid as fine bone,* and this amount substracted from the total phosphoric acid, viz., 19 per cent., leaves 9.5 *per cent. phosphoric acid as coarse bone.*

The calculated commercial value is:—

	Per cent.	Unit Value. s. d.	£ s. d.
Nitrogen as fine bone ..	2·00 ×	18 4 =	1 16 8
Nitrogen as coarse bone ..	2·00 ×	16 4 =	1 12 8
Phosphoric Acid as fine bone	9·50 ×	5 6 =	2 12 3
Phosphoric Acid as coarse bone	9·50 ×	4 6 =	2 2 9
Calculated value per ton			8 4 4
Price asked per ton			£8 15s. to £9 0s.

The calculated value of this brand of bonedust is somewhat low, and the farmer would be well advised to compute the values of other brands of bonedust before purchasing his requirements in this commodity.

Price asked per ton.

It should be borne in mind when purchasing fertilizers that the price asked per ton is free on rails at the railway station nearest the place of manufacture, and in computing values of fertilizers it is essential that due allowance should be made for any freight charges that may be involved.

For example, assuming a farmer in Gippsland requires some blood and bone fertilizer and selects three brands manufactured at Warrnambool, Geelong, and Melbourne respectively from which to make a choice.

It would be necessary when calculating their value by the unit value system to add the freight charge per ton (*a*) from Warrnambool to Melbourne, and (*b*) from Geelong to Melbourne in the case of the fertilizers manufactured at Warrnambool and Geelong respectively, before any comparison in value with the fertilizer manufactured in Melbourne could be made.

Unit Values for the Past and Present Seasons Compared.

—	Unit Value. 1931. s. d.	Unit Value. 1932. s. d.	Per cent. Increase approximately.	Per cent. Decrease approximately.
Nitrogen (Organic)—				
As Blood, Fine Bone, &c. ..	23 3	18 4	..	21·0
As Nitrate ..	19 9	21 6	8.8	..
As Coarse Bone and in Bone Fertilizer	21 0	16 4	..	22·0
As Urea ..	16 4	16 4	..	..
As Ammonia ..	13 6	11 8	..	13·5
Phosphoric Acid—				
As Water Soluble ..	4 8	4 6	..	3·5
As Citrate Soluble in Blood and Bone, &c.	4 9	4 6	..	5·3
As Citrate Insoluble—				
In Blood and Bone, &c.	3 10	4 0	4·0	..
In Ground Phosphate ..	2 11	2 6	..	14·0
Potash—				
As Sulphate ..	6 4	7 11	25·0	..
As Chloride (Muriate)	5 2	6 8	29·0	..

Generally speaking, there is a marked increase in the unit values of the imported fertilizers due, of course, to the existing economic conditions. The decrease in the unit values of the various fertilizers manufactured locally is particularly satisfactory.

The following table, which comparing the prices of the main artificial fertilizers in London and in Victoria for the past two years, may be of interest:—

Fertilizer.	Price (Average) in Victoria. 1931. £ s. d.	Price (Average) in Victoria. 1932. £ s. d.	Price in London. 1931. £ s. d.	Price in London. 1932. £ s. d.
Nitrate of Soda (15.5%)	15 2 6	16 10 0	9 12 0	8 10 0
Sulphate of Ammonia (20.6%)	13 17 0	11 19 0	9 3 0	6 10 0
Muriate of Potash (50%)	12 12 6	16 12 6	10 0 0	9 1 0
Sulphate of Potash ..	15 8 4*	19 3 4*	12 2 0†	11 0 0†
Superphosphate ..	4 15 0	4 15 0	2 17 6	2 10 0
			(4 4 3)	(3 13 3)
Bonedust	8 11 3	8 8 0	..	6 10 0

* 48·5%. † 48%.

It should be noted that Victorian superphosphate is of much higher grade (20.5% water soluble phosphoric acid) than the English article (14% water soluble phosphoric acid). When computed to equal composition, the English superphosphate is worth the figures given in brackets, but it is not claimed that the calculation is anything more than approximate.

Fertilizers Act 1928 (No. 3680).

LIST OF UNIT VALUES FOR THE YEAR 1932.

	£	s.	d.
Nitrogen, as Nitrate	1	1	6
,, organic, as Blood; Blood and Bone; Blood, Bone, and Flesh; and Fine Bone	0	18	4
,, ,, as Coarse Bone and in Bone Fertilizers	0	16	4
,, as Urea	0	16	4
,, as Ammonia	0	11	8
Phosphoric Acid—			
as Water Soluble	0	4	6
as Citrate Soluble—			
in Blood and Bone, in Animal Fertilizers, and in Mixed Fertilizers containing either or both of the foregoing	0	4	6
in all other Fertilizers	0	4	0
as Citrate Insoluble—			
in Blood and Bone, in Animal Fertilizers, and in Mixed Fertilizers containing either or both of the foregoing	0	4	0
in other Mixed Fertilizers and in Ground Phosphate	0	2	6
in other Fertilizers	0	1	0
as Fine Bone	0	5	6
as Coarse Bone	0	4	6
Potash, as Sulphate	0	7	11
,, as Chloride (muriate)	0	6	8

LIST OF FERTILIZERS REGISTERED AT THE OFFICE OF THE DIRECTOR OF AGRICULTURE UNDER THE FERTILIZERS ACT 1928 (No. 3680) FOR THE YEAR 1932.

Description of Fertilizer.	Brand.	Nitrogen.						Phosphoric Acid.				Potash.	Price asked per ton.*	Where Obtainable
		As Nitrate.	As Ammonia.	As Blood.	As Blood and Bone.	As Blood, Bone, and Flesh.	Total.	As Water Soluble.	As Citrate Soluble.	As Citrate Insoluble.	Total.			
Nitrogenous—Readily Soluble.		%	%	%	%	%	%	%	%	%	%	%	£ s. d.	
Nitrate of Soda	Sickle in diamond	15·50	..	..	..	..	15·50	..	..	..	..	..	17 10 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melbourne
,, ,,	Cresco ..	15·00	..	..	..	..	15·00	..	..	..	..	..	17 10 0	Cresco Fertilizers Ltd., Geelong
,, ,,	Pivot ..	15·50	..	..	..	..	15·50	..	..	..	..	..	14 10 0	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st.,Melb.
Nitrates of Lime and Ammonia	B.A. over S.F. in circle	15·00	·50	..	..	..	15·50	..	..	..	..	..	14 10 0	Henry H. York and Co. Pty. Ltd., 573 Lonsdale-st., Melb.
Nitrate of Ammonia with chalk	Calnitro I.G., B.A. over S.F. in circle	10·25	10·25	..	..	..	20·50	..	..	..	..	..	16 0 0	,, ,, ,, ,,
Sulphate of Ammonia	M.G. Co. in diamond	..	20·59	..	..	..	20·59	..	..	..	..	..	11 16 0	The Metropolitan Gas Co., 196 Flinders-st., Melb.
,, ,,	Pivot ..	..	20·60	..	..	..	20·60	..	..	..	..	..	11 16 0	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st.,Melb.
,, ,,	Sickle in diamond	..	20·60	..	..	..	20·60	..	..	..	..	..	12 2 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
,, ,,	Cresco ..	..	20·00	..	..	..	20·00	..	..	..	..	..	12 2 0	Cresco Fertilizers Ltd., Geelong
Urea	B.A. over S.F. in circle	..	..	..	..	..	46·00 (as urea)	..	..	..	..	..	37 10 0	Henry H. York and Co. Pty. Ltd., 573 Lonsdale-st., Melb.
Moderately Soluble.														
Dried Blood ..	T.B. & S. Brooklyn in diamond	..	..	11·60	..	..	11·60	..	..	..	..	..	9 0 0	Thomas Borthwick and Sons (A/asia) Ltd., 84 William-st., Melb.
,, ,, ..	Pannifex's ..	..	..	11·00	..	..	11·00	..	..	..	·50	1·10	11 0 0	H. C. Pannifex and Co., 26 Market-st., Melb.
,, ,, ..	Imperial ..	..	..	12·00	..	..	12·00	..	..	·75	·75	·50	9 10 0	W. Angliss and Co. (Aust.) Pty. Ltd., 42 Bourke-st., Melb.
,, ,, ..	M.C.C. Special in diamond	..	..	10·00	..	..	10·00	..	..	..	1·25	·61	9 10 0	Melbourne City Council, Town Hall, Melb.

LIST OF FERTILIZERS REGISTERED AT THE OFFICE OF THE DIRECTOR OF AGRICULTURE UNDER THE FERTILIZERS ACT 1928 (No. 3680) FOR THE YEAR 1932—*continued.*

Description of Fertilizer.	Brand.	Nitrogen.						Phosphoric Acid.				Potash as Sulphate.	Price asked per ton.*	Where Obtainable.
		As Nitrate.	As Ammonia.	As Blood.	As Blood and Bone.	As Blood, Bone, and Flesh.	Total.	As Water Soluble.	As Citrate Soluble.	As Citrate Insoluble.	Total.			
		%	%	%	%	%	%	%	%	%	%	%	£ s. d.	
Blood Manure ..	Cockbill's ..	..	..	8·50	..	..	8·50	..	..	..	1·00	..	8 10 0	J. Cockbill, 407 Post Office-place, Melb.
„ „ ..	M.C.C. in diamond	..	..	8·02	..	..	8·02	..	..	..	1·25	·61	7 15 0	Melbourne City Council, Town Hall, Melb.
„ „ ..	Sickle in diamond	..	..	7·50	..	..	7·50	..	..	..	..	..	9 0 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
„ „ ..	Nifex ..	..	..	7·50	..	..	7·50	..	..	..	1·00	·25	7 15 0	H. C. Pannifex and Co., 26 Market-st., Melb.
Slowly Soluble.														
Castor Meal ..	Alba ..	..	..	..	..	..	5·00 (as castor meal)	..	..	2·25	2·25	·75	5 15 0	Lycett Proprietary Ltd., Normanby-rd., Montague
Ground Wool Waste	J. Heiliger's ..	..	..	..	..	..	5·00 (as wool)	..	..	..	..	..	5 10 0	Joseph Heiliger, Marnock Vale, Geelong
Phosphatic—Readily Soluble.														
Superphosphate 22 per cent.	Sickle in diamond	..	..	..	..	..	..	20·50	·50	1·00	22·00	..	4 15 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
„ „	Cresco ..	..	..	..	..	..	..	20·50	·50	1·00	22·00	..	4 15 0	Cresco Fertilizers Ltd., Geelong
„ „	Pivot ..	..	..	..	..	..	..	20·50	·50	1·00	22·00	..	4 15 0	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st.,Melb.
„ „	Lamaco ..	..	..	..	..	..	..	20·50	·50	1·00	22·00	..	4 15 0	New Zealand Loan and Mercantile Agency Co. Ltd., 538 Collins-st., Melb.
„ „	Cockbill's ..	..	..	..	..	..	..	20·50	·50	1·00	22·00	..	4 15 0	J. Cockbill, 407 Post Office-place, Melb.
Moderately Soluble.														
Super. and Phosphate	Sickle in diamond	..	..	..	..	..	..	10·00	·50	18·50	29·00	..	5 0 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
„ „	Pivot ..	..	..	..	..	..	..	10·00	·50	18·50	29·00	..	4 15 0	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st.,Melb.
„ „	Cresco 50/50 Phosphate	..	..	..	..	..	..	9·16	1·84	17·40	28·40	..	5 0 0	Cresco Fertilizers Ltd., Geelong
„ „	Cresco Phosphatic Guano and Super.	..	..	..	..	..	..	4·58	4·58	11·45	20·61	..	4 5 0	„ „ „ „
Basic Phosphate	Pivot ..	..	..	..	..	..	..	..	15·50	3·00	18·50	..	5 7 6	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st.,Melb.
„ „	Sickle in diamond	..	..	..	..	..	..	..	15·50	3·20	18·70	..	6 0 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
Slowly Soluble.														
Ground Phosphate	Sickle in diamond (80%)	..	..	..	..	..	..	..	..	36.65	36.65	..	5 7 6	„ „ „ „
„ „	Pivot ..	..	..	..	..	..	..	..	..	36.50	36.50	..	4 0 0	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st.,Melb.
„ „	Pivot, very fine	..	..	..	..	..	..	..	..	36.50	36.50	..	4 10 0	„ „ „ „
Potassic—Readily Soluble.														
Muriate of Potash	Cresco ..	..	..	..	..	..	..	..	..	..	..	50.00 (as chloride)	17 15 0	Cresco Fertilizers Ltd., Geelong
„ „	Sickle in diamond	..	..	..	..	..	..	..	..	..	..	50·00 (as chloride)	15 10 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
Sulphate of Potash	„ „	..	..	..	..	..	..	..	..	..	..	48.50	18 15 0	„ „ „ „
„ „	Cresco ..	..	..	..	..	..	..	..	..	..	..	48.50	18 15 0	Cresco Fertilizers Ltd., Geelong
„	Pivot ..	..	..	..	..	..	..	..	..	..	..	49.50	20 0 0	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st.,Melb

LIST OF FERTILIZERS REGISTERED AT THE OFFICE OF THE DIRECTOR OF AGRICULTURE UNDER THE FERTILIZERS ACT 1928 (No. 3680) FOR THE YEAR 1932—*continued.*

Description of Fertilizer.	Brand.	Nitrogen.						Phosphoric Acid.				Potash as Sulphate.	Price asked per ton.*	Where Obtainable.
		As Nitrate.	As Ammonia.	As Blood.	As Blood and Bone.	As Blood, Bone, and Flesh.	Total.	As Water Soluble.	As Citrate Soluble.	As Citrate Insoluble.	Total.			
Containing Nitrogen and Phosphoric Acid—Readily Soluble.		%	%	%	%	%	%	%	%	%	%	%	£ s. d.	
Super. and Ammonia	Sickle in diamond, No. 1	..	2·85	..	..	..	2·85	17·57	·39	·80	18 76	..	6 15 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
,, ,,	Pivot, I. ..	..	2·90	..	..	..	2·90	17·40	·40	·80	18·60	..	6 12 0	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st.,Melb.
,, ,,	Cresco (6 in 1)	..	2·85	..	..	..	2·85	17·48	·42	·85	18·75	..	7 5 0	Cresco Fertilizers Ltd., Geelong
,, ,,	Pivot, II. ..	..	5·00	..	..	..	5·00	15·30	·30	·80	16·40	..	7 10 0	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st.,Melb.
,, ,,	Sickle in diamond, No. 2	..	5·00	..	..	..	5·00	15·37	·37	·76	16·50	..	7 15 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
,, ,,	Pivot, III. ..	..	10·00	..	..	..	10·00	10·20	·20	·50	10·90	..	9 15 0	The Phosphate Co-operative Co. of Aust. Ltd 447 Lit. Collins-st.,Melb.
,, ,,	Sickle in diamond, No. 3	..	6·87	..	..	..	6·87	13·66	·34	·66	14·66	..	8 15 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
Nitro - Superphosphate	Sickle in diamond	..	1·50	..	.	·50	2·00	16·69	1·12	2·01	19·82	..	6 15 0	,, ,, ,, ,,
,, ,,	Cresco ..	..	1·50	..	·50	..	2·00	16·39	1·10	1·70	19·19	..	7 0 0	Cresco Fertilizers Ltd., Geelong
Di-ammonium Phosphate I.G.	BA over SF in circle	..	20·60	..	..	..	20·60	53·00	..	..	53·00	..	33 0 0	Henry H. York and Co. Pty. Ltd., 573 Lonsdale-st., Melb.
Moderately Soluble.														
Ammonia and Phosphate	Cresco ..	..	2·00	..	..	..	2·00	8·30	1·60	15·70	25·60	..	6 5 0	Cresco Fertilizers Ltd., Geelong
Blood, Bone, and Super.	Sickle in diamond	..	..	..	..	2·50	2·50	12·51	1·43	2·96	16·90	..	7 10 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
,, ,,	Cockbill's ..	..	..	..	2·50	..	2·50	12·51	1·43	2·96	16·90	..	7 10 0	J. Cockbill, 407 Post Office-place, Melb.
,, ,,	Rohs in circle..	..	..	..	3·00	..	3·00	8·15	1·00	6·00	15·15	..	7 12 6	P. Rohs Pty. Ltd., Bridge-st., Bendigo
Bone and Super.	Sickle in diamond, No. 1	..	..	..	..	2·00	2·00	11·38	3·08	5·32	19·78	..	6 17 6	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
,, ,,	Cresco ..	..	..	..	..	..	2·00 (as bone)	9·50	3·90	3·00	16·40	..	7 17 6	Cresco Fertilizers Ltd., Geelong
,, ,,	J. A. Dundas'	..	..	..	..	2·25	2·25	9·99	5·16	5·58	20·73	..	7 10 0	J. A. Dundas, Dynon-rd., Footscray
Bone Fertilizer and Super.	Elsworth's ..	..	..	..	..	..	1·50 (as bone)	11·00	2·50	5·00	18·50	..	6 10 0	W. R. Elsworth, 128 Victoria-st., Ballarat
,, ,,	Rohs in circle..	..	..	..	..	..	1·50 (as bone)	9·67	2·34	4·75	16·76	..	7 10 0	P. Rohs Pty. Ltd., Bridge-st., Bendigo
Super. and Bone	Sickle in diamond, No. 2	..	..	..	..	1·00	1·00	15·95	1·79	3·16	20·90	..	6 0 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
,, ,,	Cresco ..	..	..	..	..	1·00	1·00	16·10	1·10	3·60	20·80	..	6 15 0	Cresco Fertilizers Ltd., Geelong
Blood and Bone	Sickle in diamond	..	..	..	..	5·00	5·00	..	6·00	10·00	16·00	..	8 0 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
,, ,,	J. A. Dundas'	..	..	..	..	4·50	4·50	..	7·14	13·61	20·75	..	7 10 0	J. A. Dundas, Dynon-rd., Footscray
,, ,,	Apollo ..	..	..	..	5·00	..	5·00	..	4·00	12·00	16·00	..	8 10 0	J. Kitchen and Sons Pty. Ltd., Ingles-st., Port Melb.
,, ,,	Cockbill's ..	..	..	..	..	5·25	5·25	..	3·00	9·00	12·00	..	8 10 0	J. Cockbill, 407 Post Office-place, Melb.
,, ,,	Pannifex's No. 1	..	..	..	..	6·35	6·35	..	5·00	6·50	11·50	..	8 15 0	H. C. Pannifex and Co., 26 Market-st., Melb.
,, ,,	,, No. 2	..	..	..	..	7·17	7·17	..	5·00	6·99	11·99	..	9 0 0	,, ,, ,, ,,
,, ,,	,, No. 3	..	..	..	..	6·90	6·90	..	4·00	5·50	9·50	..	8 10 0	,, ,, ,, ,,
,, ,,	,, No. 4	..	..	..	8·00	..	8·00	..	5·44	2·00	7·44	..	8 10 0	,, ,, ,, ,,

LIST OF FERTILIZERS REGISTERED AT THE OFFICE OF THE DIRECTOR OF AGRICULTURE UNDER THE FERTILIZERS ACT 1928 (No. 3680) FOR THE YEAR 1932—*continued.*

Description of Fertilizer.	Brand.	Nitrogen.						Phosphoric Acid.				Potash as Sulphate.	Price asked per ton.*	Where Obtainable.
		As Nitrate.	As Ammonia.	As Blood.	As Blood and Bone.	As Blood, Bone, and Flesh.	Total.	As Water Soluble.	As Citrate Soluble.	As Citrate Insoluble.	Total.			
		%	%	%	%	%	%	%	%	%	%	%	£ s. d.	
Blood and Bone	Rohs in circle..	..	..	..	6·00	..	6·00	..	3·80	12·70	16·50	..	9 0 0	P. Rohs Pty. Ltd., Bridge-st., Bendigo
,, ,,	Fitzgerald's ..	..	..	..	5·20	..	5·20	..	9·75	4·40	14·15	..	8 0 0	P. Fitzgerald and Sons, Warrigal-rd., Bentleigh
,, ,,	T.B. & S. in diamond—Brooklyn	..	..	..	6·00	..	6·00	..	9·00	4·00	13·00	..	7 0 0	Thomas Borthwick and Sons (A/asia) Ltd., 84 William-st., Melb.
,, ,,	T.B. & S. in diamond—Lighthouse	..	..	..	6·00	..	6·00	..	5·00	2·00	7·00	..	7 0 0	,, ,, ,, ,,
,, ,,	Cockatoo ..	..	..	..	..	4·56	4·56	..	5·90	5·88	11·78	..	6 0 0	R. Fordham, Cressy-rd., Camperdown
,, ,,	Corio ..	..	..	..	4·00	..	4·00	..	6·00	8·00	14·00	..	6 10 0	The Corio Trading Co. Pty. Ltd., Moorabool-st., Geelong
,, ,,	C.K. ..	..	..	..	4·65	..	4·65	..	7·06	7·44	14·50	..	7 10 0	Joseph Reid, Elliminyt
,, ,,	Pridham's ..	..	..	..	5·00	..	5·00	..	8·30	5·70	14·00	..	6 10 0	W. Pridham Pty. Ltd., Evans-st., Braybrook
,, ,,	W. & M. in circle	..	..	..	6·00	..	6·00	..	4·50	5·50	10·00	..	9 0 0	Western and Murray Co-operative Bacon Co. Ltd., 522 Flinders-lane, Melbourne
,, ,,	Imperial ..	..	..	..	5·00	..	5·00	..	5·00	11·00	16·00	..	6 10 0	W. Angliss & Co. (Aust.) Pty. Ltd., 42 Bourke-street, Melbourne
,, ,,	King's Geelong	..	..	..	5·00	..	5·00	..	6·90	8·60	15·50	..	8 15 0	Joseph C. King & Sons Pty. Ltd., Marshall
Animal Fertilizer	Fertbone ..	..	..	..	..	5·00	5·00	..	4·00	8·00	12·00	..	7 10 0	H. C. Pannifex and Co., 26 Market-st., Melb.
,, ,,	Pannifex's No. 2	..	..	..	..	4·50	4·50	..	5·00	12·00	17·00	..	7 15 0	,, ,, ,, ,,
,, ,,	Pannifex's No. 3	..	..	..	..	5·50	5·50	..	5·00	10·00	15·00	..	8 0 0	,, ,, ,, ,,
,, ,,	Pannifex's No. 4	..	..	..	..	6·00	6·00	..	5·00	7·00	12·00	..	8 15 0	,, ,, ,, ,,
,, ,,	Fitzgerald's ..	..	..	..	..	3·50	3·50	..	10·25	7·75	18·00	..	8 0 0	P. Fitzgerald and Sons, Warrigal-rd., Bentleigh
,, ,,	A.N.A. Surprise	..	..	..	..	5·00	5·00	..	4·00	10·00	14·00	..	8 10 0	G. W. Pennell, Burke-st., Braybrook
Bone Fertilizer	Elsworth's ..	..	..	..	..	..	3·00 (as bone)	1·50	4·00	9·50	15·00	..	7 10 0	W. R. Elsworth, 128 Victoria-st., Ballarat
,, ,,	King's, Geelong	..	..	..	..	2·57	2·57	..	7·36	2·87	10·73	..	6 10 0	Joseph C. King and Sons Pty. Ltd., Marshall
Mixed Manure ..	"Humo-Phos."	..	1·28	1·03 (as organic)	..	..	2·31	..	..	5·46	5·46	..	4 14 0	Peninsula Lime and Fertilizer Co. Pty. Ltd., 70 Elizabeth-st., Melb.
Wool Waste and Super.	Bruno ..	..	..	..	..	..	3·00 (as wool)	8·00	..	·78	8·78	..	6 0 0	Joseph Heiliger, Marnock Vale, Geelong
Containing Nitrogen, Phosphoric Acid, and Potash.														
Market Garden Manure	Cresco ..	..	1·50	..	1·56	..	3·06	11·65	1·49	3·26	16·40	2·42	8 10 0	Cresco Fertilizers Ltd., Geelong
,, ,,	Sickle in diamond	..	1·50	..	..	1·56	3·06	10·82	2·44	4·25	17·51	2·42	8 10 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.
Complete Manure	Sickle in diamond, No. 1	..	2·50	..	..	..	2·50	14·87	·36	·72	15·95	7·26	9 0 0	,, ,, ,, ,,
,, ,,	Sickle in diamond, No. 2	..	1·00	1·00	..	..	2·00	14·85	·36	·72	15·93	4·85	8 10 0	,, ,, ,, ,,
,, ,,	Sickle in diamond, No. 3	..	8·00	..	..	..	8·00	10·19	·25	·50	10·94	5·00	11 0 0	,, ,, ,, ,,
,, ,,	Sickle in diamond, No. 4	..	1·00	..	..	1·40	2·40	10·94	2·22	3·86	17·02	5·00	9 5 0	,, ,, ,, ,,
,, ,,	Sickle in diamond, No. 5	..	3·33	..	..	..	3·33	13·68	·33	·67	14·68	8·07	10 0 0	,, ,, ,, ,,
Mixed Manure ..	Cresco ..	..	1·50	..	..	..	1·50	7·10	1·40	13·50	22·00	7·50	8 2 6	Cresco Fertilizers Ltd., Geelong
,, ,,	Cresco No. 2 ..	..	1·00	..	1·40	..	2·40	11·25	2·00	4·50	17·75	5·00	9 5 0	,, ,, ,, ,,
Complete Manure	Pivot IV. ..	..	2·90	..	..	..	2·90	14·30	·30	·70	15·30	6·90	8 2 0	The Phosphate Co-operative Co. of Aust. Ltd., 447 Lit. Collins-st., Melb,
,, ,,	Pivot V. ..	..	8·20	..	..	..	8·20	8·20	·20	·40	8·80	9·60	11 0 0	,, ,, ,, ,,
Horticultural Manure	Sickle in diamond	..	3·00	..	..	..	3·00	10·78	·26	·53	11·57	9·70	10 5 0	Commonwealth Fertilizers and Chemicals Ltd., 65 William-st., Melb.

LIST OF FERTILIZERS REGISTERED AT THE OFFICE OF THE DIRECTOR OF AGRICULTURE UNDER THE FERTILIZERS ACT 1928 (No. 3680) FOR THE YEAR 1932—*continued.*

Description of Fertilizer.	Brand.	Nitrogen.						Phosphoric Acid.				Potash as Sulphate.	Price asked per ton.	Where Obtainable.
		As Nitrate.	As Ammonia.	As Blood.	As Blood and Bone.	As Blood, Bone, and Fleth.	Total.	As Water Soluble.	As Citrate Soluble.	As Citrate Insoluble.	Total.			
		%	%	%	%	%	%	%	%	%	%	%	£ s. d.	
Nitrophoska I.G.	BA over SF in circle, No. 3	4·50	11·50	..	..	..	16·00	16·50	..	..	16·50	21·50 (as chloride)	22 15 0	Henry H. York and Co. Pty. Ltd., 573 Lonsdale-st., Melb.
„ „	BA over SF in circle, No. 4	5·00	10·50	..	..	..	15·50	15·00	1·00	..	16·00	19·00	22 15 0	„ „ „ „
Mixed Manure ..	Wooltana ..	..	1·19	·60 (as organic	..	..	1·79	1·20	6·38	19·97	27·55	3·71 (as chloride)	9 19 3	H. C. Sleigh, 582 Little Collins-st., Melb.
„ „ ..	Wooltana Special	..	3·61	·36 (as organic)	..	..	3·97	7·42	6·76	11·10	25·28	2·42 (as chloride)	11 11 5	„ „ „ „

Description of Fertilizer.	Brand.	Nitrogen	Phosphoric Acid.	Mechanical Condition.		Price asked per ton.*	Where Obtainable.
				Fine Bone.	Coarse Bone.		
		%	%	%	%	£ s. d.	
Bonedust ..	Pannifex's No. 1	2·00	24·00	50	50	9 0 0	H. C. Pannifex and Co., 26 Market-street, Melbourne
„ ..	Pannifex's No. 2	4·00	19·00	50	50	9 0 0	„ „ „ „ „
„ ..	Rohs in circle..	4·00	19·00	50	50	8 15 0	P. Rohs Pty. Ltd., Bridge-street, Bendigo
„ ..	Jeetho ..	3·88	23·65	60	40	10 0 0	Lovell and Anderson, Korumburra
„ ..	Bailey Bros. ..	3·00	19·00	50	50	7 10 0	Bailey Bros., 8 Sturt-street, Ballarat
„ ..	Ox	3·95	21·36	50	50	7 10 0	Thomas Brown Successors, Gray-street, Hamilton
„ ..	B.	3·35	23·20	60	40	7 0 0	Thomas Benson, Woodford

* F.O.R. station nearest place of manufacture or, when imported, Melbourne.

Milk Fever

(*Continued from page 20.*)

successful, and is particularly useful in cows which are affected with mastitis, or those which do not respond to the air-inflation treatment. In the hands of inexperienced persons, however, this method is extremely dangerous, and may cause inflammation of the blood vessels or death by embolism. The solution must be prepared very carefully and injected very slowly.

Those discoveries open up a new vista in respect of preventative treatment. Sunlight and certain food factors, notably Vitamin D, stimulate the absorption of calcium-phosphate. In an experiment carried out by Greig on a cow which had developed acute milk fever on seven successive years, feeding the animal with foods rich in that vitamin reduced the attack to a very mild one, with spontaneous recovery. This treatment may be improved, and give even better results.

Meanwhile, farmers would be well advised to give cows daily exercise and feed them sparingly just prior to calving. Susceptible cows should not be milked completely dry during the first two or three days of milking or the calf should be left with them. A good salt lick containing at least 30 per cent. of bone flour or 15 per cent. of di-calcic phosphate should be made available to all dairy cattle.

In conclusion, the following points may be stressed:—

1. Do not be persuaded to drench cows affected with milk fever. Drenches frequently cause pneumonia and death.

2. Do not delay inflation of the udder, but do not be in such a hurry that you neglect proper antiseptic precautions. Dirty air injected into dirty udders with dirty instruments by dirty hands will cause mastitis, and will ruin your cow for milk production.

Professional Papers

[This section is devoted to professional papers and articles of a scientific character.]

"The Development of Accuracy in Agricultural Experiments"

"A Review of Certain Types of Plot Technique and Their Application to Cereal Trials in Victoria"

By H. C. Forster, M.Ag.Sc., and A. J. Vasey, B.Ag.Sc., Agricultural Research Officers.
(State Research Farm, Werribee.)

THE interpretation of experimental results has confronted research workers through all ages. Agricultural experiments in particular have shown great variation, and the inconsistency of results from field to field and from year to year have confounded the most accurate observers. The natural variation of the plant, the varying response to soil type, to situation, and to season, all play their part in the resultant yield, and it has been necessary, therefore, to evolve methods of examination of field trials which will allow of the correct interpretation of results.

The purpose of this article is to show the application of these methods to agricultural experiments, using the trials at the State Research Farm, Werribee, as examples; and to show, further, the accuracy which has been obtained and the results, beneficial or otherwise, which have attended the introduction of each new development. It is hoped that this summary of the experience gained at Werribee with the various methods will serve as a guide to the many experimenters who are working under somewhat similar Australian conditions, and who find but limited time to concentrate on the application of statistical methods to their trials. Although much of the work has been carried out on cereals, the methods may be as successfully applied to other allied branches of agriculture and horticulture.

In order to obtain a correct interpretation of these variable plot results, the assistance has been sought of the statistician who, by means of certain laws, has been able to obtain a measure of the degree of variation of the yields. It has been demonstrated by a number of uniformity trials (11, 18) that this variation in yields is present to a very large degree, even in areas which have been selected "as far as the eye could judge, to be an even area of wheat." The 160 plots into which the selected "uniform" acre in the Werribee trial (11) was divided, varied from 108 to 164 ounces per plot, a variation of 20.6 per cent. on either side of the mean. The further important fact was demonstrated, that the frequency curve of the yields of these plots agreed with what is known as the "normal curve of error," and that, therefore, certain statistical formulae could be employed to estimate the variation of the results.

The definition and the methods of determination of such terms as the "Mean," the "Probable Error," the "Standard Deviation," and the "Standard Error," can best be found in text-books on the subject (24, 25). It will suffice to give here a brief definition of two of these measures of variation, since they are quoted frequently later:—

Standard Deviation.—The "Standard Deviation" (S.D.) of a single plot is the square root of the mean square deviation or, more simply, it is obtained by summing the squares of the deviations of each yield from the mean yield, dividing by "N" the number of plots, and finally taking the square root. Thus $S.D. = \sqrt{\frac{\text{Sum } d^2}{N.}}$. It is desirable that "N" should be large in order to obtain a representative sample of the possible variation, but it often happens in agricultural experiments that the number of plots of similar treatment is low. "Student" (20.) has pointed out that the S.D. obtained in this manner gives too small a value, and that a more correct result is obtained by dividing by "N—1."

Standard Error.—In considering the average yield of a number of plots, we would expect the range of deviation from the mean to be smaller. The measure of this range, which is termed the "Standard Error" (S.E.), is obtained by dividing the S.D. by the square root of the number of plots considered in the average. Thus the

$$\text{S.E.} = \frac{\text{S.D.}}{\sqrt{n.}}$$

Accordingly, if the plots are placed on soils which are apparently uniform, we have indications of the lines along which experiments must be designed if the measure of their variation is to be satisfactorily low. Firstly, in order to give the range of their variation, the experiment must contain a number of plots receiving similar treatment, and, secondly, the figure denoting the yield of that series of plots will be more accurate, and therefore reliable, if it be the average of a number of plots of similar treatment. This principle of the need for repetition of plots has been termed "replication," and the measure of the variation of the plots, the S.E., has been termed the "error" of the experiment.

In comparing, then, two varieties which have each been sown in a replicate manner, how is the agricultural worker to interpret the result? The answer has been supplied by the statisticians, who first determined the error of the difference between the two varieties from the formula $E_{x+y} = \sqrt{E_x^2 + E_y^2}$ where

E_x = error of variety X,
E_y = error of variety Y, and
E_{x+y} = error of the difference between X and Y.

They then adopted a standard that when the difference between two varieties was greater than twice the S.E., the result was dependable or, as they termed it, "significant."*

The uniformity trial already mentioned (11) further showed that the variations occurring between yields of plots in any one season were of two main classes—(*a*) the large regular errors due to definite soil gradients from side to side in the paddock, and (*b*) the small casual or random errors, due either to local "patches" of soil, or to uneven seeding, manuring, harvesting, hare tracks, birds, &c. As it is from a more intense study of these variations that the later methods of plot technique benefit, a consideration of these errors as they occurred in the trial may not be out of place.

Figure 1 demonstrates these two types of variations—

(*a*) the gradient type—by the general trends from east to west in one row, and the dip in fertility in the north-south row, and

(*b*) the random type—by the large variations between adjacent plots in both rows.

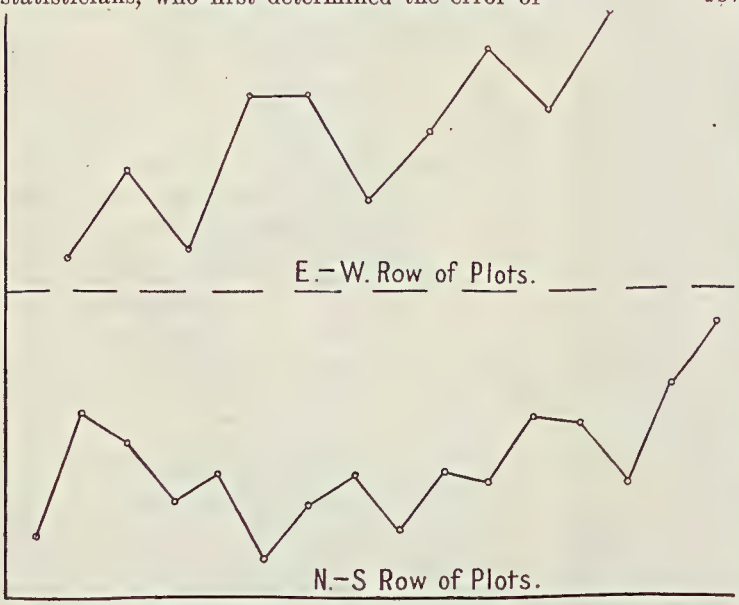


Fig. 1.—Showing types of errors in a Uniformity Trial at Werribee. Weights of adjacent plots in two random directions.

On account of the random nature of this latter group of errors, it has been stressed by all authorities that, if an adequate idea of the soil variation is to be obtained, the replicates of any one treatment must be placed at random over the area of the trial. Attempts to control the order of the plots will result in a bias, which may cause either over- or under-estimation of the error (23). As shown later, it becomes necessary in certain types of sampling to regulate the order of the plots in that each replicate is assigned to a certain portion of the area to be sampled. The position of the sample or plot within that portion, however, must be selected at random.

* This standard is equivalent to three times the "Probable Error."

Single Plot Trials.

In turning now to a consideration of the development of plot technique at Werribee, the position before 1927 was dependent entirely on yields from single plot trials. Control varieties were interspersed among the varieties at intervals of every ten plots, and the variety was compared with the nearest control. The trials were continued in most cases from year to year, and in the course of time the average yields over the various periods showed more or less consistency. A study of the variation of a single plot in the uniformity trial showed the S.D. to be 5 per cent. of the mean yield. Thus, in comparing differences between two varieties or treatments, only those larger than 15 per cent. could be considered significant in any one year. Typical results from the variety trials show how difficult of interpretation the results were. (See Table I.)

Not only were the results subject to the variations due to soil differences, but also the effect of the important climatic factor played a large part. In spite of these marked variations, this method was capable of demonstrating many fundamental truths, among which may be numbered the increase in yields of cereals with applications of superphosphate, the failure of certain basic phosphates to give a similar response, and, as the table shows, the improved yielding ability of certain varieties, such as Free Gallipoli, over the standard Federation. The improvements were all of a sufficiently large nature to outweigh the natural variation. The large single plots, too, lent themselves admirably for demonstration purposes, and have not been surpassed for this purpose to the present day.

Various attempts to improve the position have been instituted by increasing the number of control plots, and the calculation by interpolation of the probable yield of the controls in the intermediate positions. Such methods only achieve partial success, since they take cognizance of the soil gradient variation only, and do not attempt to control the second random type of error.

Replicated Plots.

The uniformity trial demonstrated the important fact that random replication was necessary if satisfactory results were to be obtained. Therefore, in the first modification of design the plots were simply randomized over the whole area.

Randomized Chessboard Trials.†

The plan of such a system of plots is indicated in Figure 2. To allow of a dependable estimation of the error of any one variety, it was the custom to use a large number of replicates.

The resultant yields were separated into groups of the same variety, and the error calculated for each set of plots. Comparisons were then made between varieties, and only those with significant differences were considered to have survived the trial. In this system, therefore, the error of the experiment is a combination of both types of variation, and as such will only give significance to fairly large differences.

Beavan Half-drill Strip Plots.

A most important advance was made when a suggestion of Dr. Beavan, of Warminster, was put into practice. As early as 1911 "Student" (18) had pointed out that pairs of closely adjacent plots were subject to very similar soil

† This type of method has also been termed "Bessel's method" (20).

Table 1.—Yields of Four Varieties from the Variety Plots, Werribee, 1923–1930.

Year.	Variety.			
	Yandilla King.	Federation.	Free Gallipoli.	Major.
	Bus/ac.	Bus./ac.	Bus./ac.	Bus./ac.
1923	27·2	28·4	..	32·3
1924	25·8	22·1	27·6	32·6
1925	13·7	16·1	18·2	13·3
1926	18·8	23·2	26·0	25·5
1927	16·1	22·1	23·0	19·9
1928	8·9	7·9	10·2	7·3
1929	21·2	22·3	24·5	23·6
1930	22·2	18·7	25·6	25·0

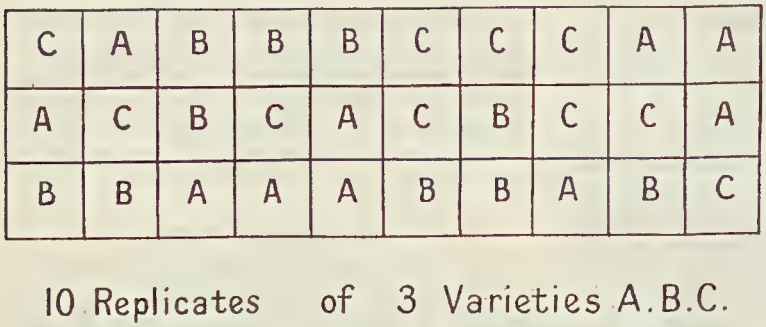


Fig. 2.—Plan showing design of plots in a Randomized Chessboard Method.

conditions, and that, therefore, the "error" of the difference between the members of the pairs would be much reduced. Dr. Beavan (2) suggested that the variety and its control should be the members of the pair, and that these should be sown from either half of a drill, the central hoe of which had been blocked. In this way not only would the pairs of plots experience similar soil conditions, but also the plots themselves would be subject to similar variations in seeding and manuring. Successive runs of the drill would thus give an order of plots A X X A, A X X A, where A is the variety, and X the control. By this means the effect of any soil gradients from side to side of the field would be balanced. In the calculation of results (see appendix), the variation of the differences between pairs of plots are alone considered, and a ratio, "Z," between the mean and the error of these differences is determined. A series of tables (15) have been prepared which show the significance of any value of "Z" for the given number of replications used.

This method has been used along certain lines at Werribee, and has been attended with great success. The actual procedure is modified somewhat to conform with local practices. For instance, in order to allow of the "stripping" of the plots at harvest, the path has been increased to 2 feet. As a result of certain studies which have shown that grain size varies considerably with different varieties, it has been thought advisable that the varieties should be sown at varying rates of seed in order that comparable populations of plants should be tested. Accordingly, the use of the drill has been confined to one plot at a time. The order A X X A, A X X A, however, has been preserved, and for each trial eight replicates of 1/40th acre plots have been used. To simplify the procedure it has been the custom to sow four replicates of twice the length, and at harvest to cut the plots in half, and test each portion separately. (Fig. 3.)

This development marked a distinct advance, since it eliminated to a large degree the soil variant factor. The pairing of treatment and control in adjacent plots served to eliminate the larger soil "patches," while the balancing of the order of plots in successive pairs avoided the soil gradient factor. It has served its best purpose in comparing new selections against the original strains, a good example being the improvement shown by the new selection, 4H, over the original strain of Ranee.

That the error of this type of trial has been satisfactorily reduced is shown by the figures from the Werribee trials. The average S.E. percentage of a single comparison of two varieties in eighteen trials conducted during 1927-1930 is as low as 2 per cent., which compares more than favorably with the 8 per cent. error for the old single-plot trials.

This method has certain disadvantages which soon became apparent. The first and most important is in the comparison between the different varieties tested in any one year. Although the Beavan method is admirably

Table II.—A Comparison of Ranee and a New Selection, 4H, by a Beavan Trial, Werribee, 1927–1929.

Year.	Ranee Yield.	Ranee 4H. Yield.	Increase.	Significance.
	Bus./ac.	Bus./ac.	Bus./ac.	
1927	19·1	22·6	3·5	1,000's : 1
1928	12·9	15·6	2·7	1,000's : 1
1929	27·5	31·3	3·8	999 : 1

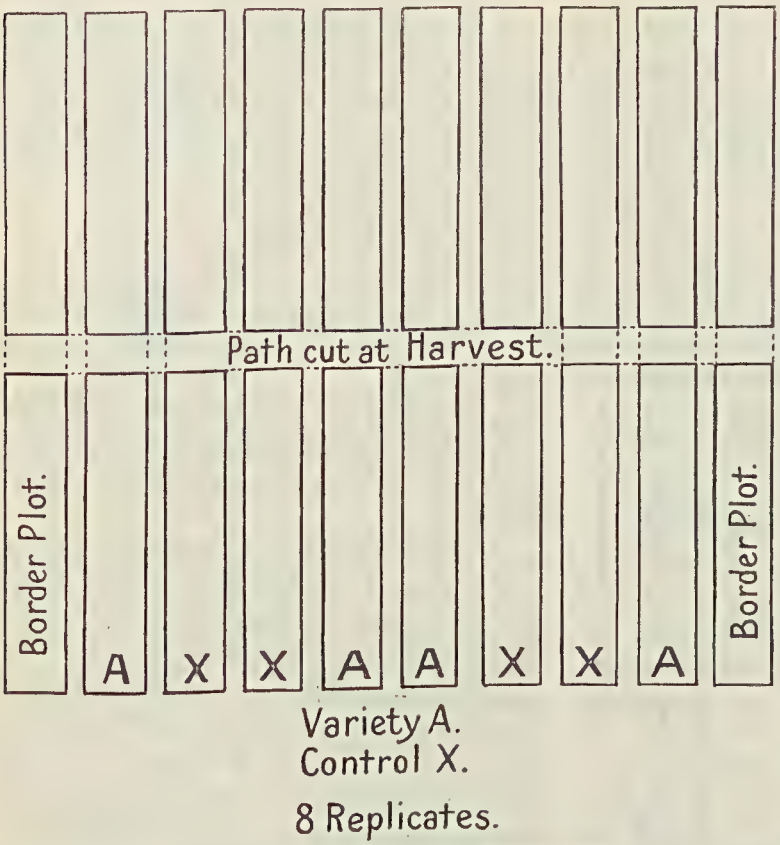


Fig. 3.—Plan of the Beavan Paired Trials.

suited to test any one variety or treatment against the control, the practice of extending the comparison beyond the one trial to include all the varieties or treatments tested is open to question. A second disadvantage of this type of design is the largeness of the area required to test six or eight varieties, due to the number of control plots. Allowing six replications of 1/40th acre plots, together with a suitable path, the area required for six varieties is approximately 2 acres. The need for such a large area increases the difficulty of selecting an even area of soil, and the justification of the comparison between varieties is destroyed proportionately to the extent to which variation occurs.

A slight improvement in the reduction of the area involved may be obtained by designing the plots in the following manner:—A X B, B X A, &c., where A and B are two varieties to be tested against the control X. The results are calculated by Student's method as before, the various pairs of A and X, and of B and X being used to obtain the significance.

"Deviation from the Mean" Method.

From a consideration of developments up to this point it is obvious that any further improvement must be along the lines of grouping the varieties or treatments in question into one block for comparison, the replication being obtained by repeating the whole block the required number of times. It was recognized, also, that the error calculated from a few number of replicates of each variety would in itself be unreliable. A much more accurate estimate of the error of the experiment would be obtained if all the plots in the trial were considered. Accordingly a method of treatment of the results was suggested (12) whereby the percentage variation from the mean of each variety was used in the calculation of the error. A much larger number of results was thus available for the determination of the variation of the yields. Although this method of analysis may obviate the need for so many replications, the error of the experiment is larger than that of the Beavan method, since no allowance has been made for soil variation.

Engledow and Yule's Method.

Engledow and Yule (8) combining this principle with that of "Student's," suggested a better method of analysis of the results from this block type of lay-out. They extended "Student's" assumption that adjacent plots would experience similar soil conditions to include all the plots in any one block. They sowed their varieties in a definite order as indicated in Fig. 4.

In treating the results, they first expressed the yields of all the plots of variety A as a deviation from the mean yield of A, and similarly with the other varieties. Then, applying "Student's" principle, they determined the differences between the respective pairs of A and

B, A and C, B and C, &c., and from the error of each set of differences arrived at a mean error for the whole experiment. Significance was again determined in the usual manner. Although this method marked a definite stage in the improvement in technique, it coincided with a still more important system of analysis, and has not therefore appeared in much use. The calculations involved are very extensive, and the authors recognized that the extension of "Student's" assumption to include all the plots in the block was not always justified. The systematic order of the varieties in the trial

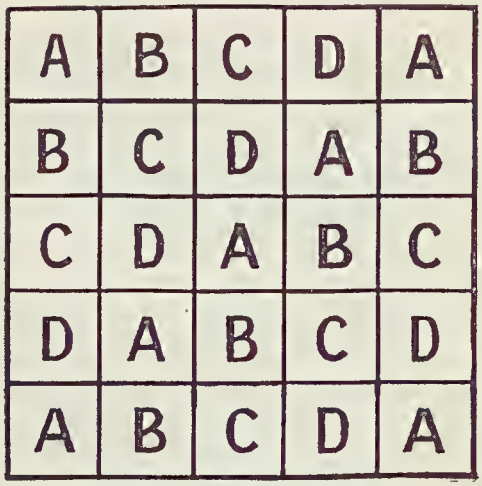


Fig. 4.—Plan of layout in Engledow and Yule's Method of Analysis.

is also open to question, since it does not permit of the correct estimate of the random soil variations.

Randomized Block Experiments.

At about this same period certain principles were put forward by "Student" (22) and R. A. Fisher (9), which have altered the whole aspect of examination of the results. Before proceeding further with these principles, it might be as well to halt a moment and examine the types of variation which occur in a trial designed on the block basis. From a consideration of the variation of each plot from the general mean of all the plots, regardless of treatment or position, we have an indication of (*a*) the total variation within the experiment. This total variation is made up of several portions—(*b*) the variation due to differ varieties or treatments, (*c*) the variation due to the gradual soil gradients from side to side of the field, and (*d*) that due to the smaller patchy effects of soil and other factors.

(*a*) Total Variation
- (*b*) Treatment or Variety,
- (*c*) Soil Gradients,
- (*d*) Random Causes.
  - Patches of soil.
  - Bird damage, drainage, &c.
  - Seeding irregularities, &c.

If now we can get an indication of the real values of these different types of variation by a sound statistical method, we may be able to determine their relative importance in the experiment.

"Student" and Fisher's principles are concerned with the recognition of these variations and the actual determination of values to be allotted to them. The method has been termed the "Analysis of Variance," since the total variation or "variance" is analysed into its component portions. The variation due to irregular causes, viz., the "(*d*)" type, is the measure of the "error" of the experiment, and the differences are considered significant when the variation due to treatment is significantly greater than that due to error.

It is not intended in this article to attempt to consider any but the broad principles of the methods, since these alone are essential to show the development. Typical examples are included in the appendix, but for more complete information the reader is referred to several excellent articles on this subject. (10, 16.)

Provided that the order of the plots in any one block is determined by random selection, Fisher obtains the values for these different portions of the total variation in the following manner. As in the case of earlier methods, the squares of deviations from the mean are first obtained. These are then summed as follows:—

(*a*) *the Total Variation*—from the sum of the squares of the deviations of all the plots from the general mean,

(*b*) *the Treatment Variation*—from the sum of the squares of the deviations of the treatment totals from the mean,

(*c*) *the Soil Gradient Variation*—since each block contains one plot only of each treatment, the block totals may

be considered as comparable entities, and the variation between blocks thus gives a measure of the soil gradient error. The sum of squares is obtained, therefore, from the squares of the deviations of the block totals from the mean.

(*d*) *the Random Variation*—the remaining variation is due to these random causes, so that the sum of squares is obtained in the simplest manner by subtracting the (*b*) and the (*c*) portions from the total sum of squares.

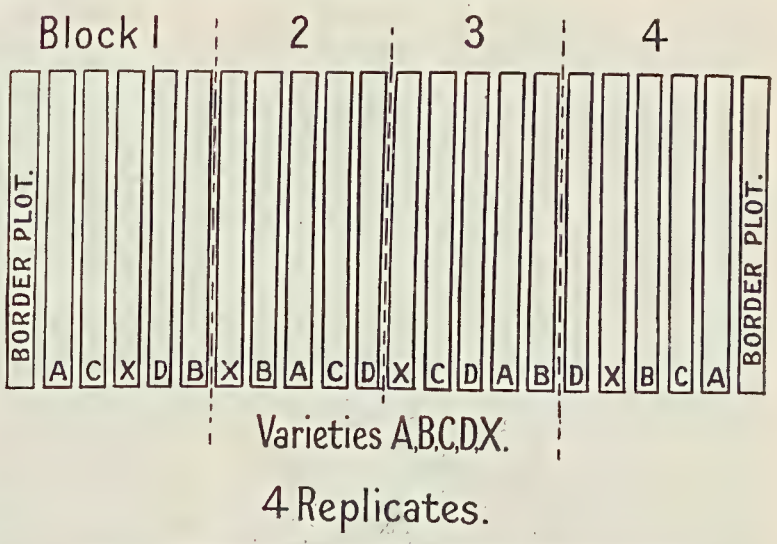


Fig. 5.—Plan of lay-out in a Randomized Block Method.

In most earlier methods the mean square deviation was obtained by dividing by the number of plots concerned in each case. Fisher, however, uses a factor which he has termed the "Degrees of Freedom." This represents the number of independent comparisons between the plots, and is, in practice, one less than the number of plots concerned. Each of the sums of the squared deviations is divided by the appropriate "Degrees of Freedom" to give the "Mean Square Deviation" for the respective portions of the variation. There remains, then, the comparison of these figures for significance, and in order to simplify this Fisher has designed a table, the "z" table, based on the logarithmic functions of these values, for certain probabilities of occurrence.

In an experiment of this type, then, it was possible to test six or seven treatments, replicating each block four or five times, and from the results to eliminate soil variation. The errors obtained from this type of analysis, since they allow for the soil variant factor, compare favorably with that derived from the Beavan method.

It has this big advantage over the Beavan trial, namely, that the comparison between all varieties is justified, while no sacrifice is made in the accuracy of the experiment. Further, the area involved in the trial is considerably smaller, and thus the difficulty in selecting even sites is reduced. Another advantage in favour of the "block" method is the ease with which ancillary characters of cereal varieties, such as "standing," "shattering," &c., of the heads, which are such an essential part of wheat breeding, may be compared, and, lastly, the adaptability of the blocks for demonstration purposes to visiting farmers, without sacrificing any accuracy in the comparison of results. Certain disadvantages have been claimed in that

TABLE III.—A TYPICAL ANALYSIS OF VARIANCE OF A R.B. TRIAL WITH FOUR STRAINS OF GALLIPOLI, WERRIBEE, 1930.

Variation Due to—	Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}$ loge (Mean Square).
Blocks	4	21·46	..	..
Varieties	3	134·45	48·82	1·9376
Remainder (error)	12	26·26	2·19	·3919
Total	19	182·17	..	..

the irregular arrangement of plots increases the likelihood of mixing the seed at sowing or in recording weights at harvest. Further, to the average person the mathematics of the method present a problem which is further accentuated by the use, in many text-books, of obscure technical phrases. However, the advantages to be gained from a study of results by the "Analysis of Variance" justify any extra care that may be necessary in field work, and the experimenter will find that, with the help of a set of tables such as Barlow's (3), the figures do not present an insurmountable problem.

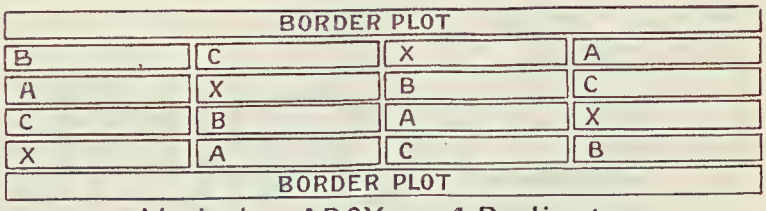


Fig. 6.—Plan of lay-out in a Latin Square Method.

A further modification in design was also suggested, and has been called a "Latin Square." In this type of lay-out the plots are planned in a square formation, and the varieties or treatments are scattered so that any one variety occurs only once in each row or column. In this design, therefore, the experiment may be considered to consist of blocks in two directions, either horizontally (rows) or vertically (columns). In considering the "Analysis of Variance," the variation for soil gradients may be determined in two directions, and thus the remaining error may be reduced still further.

This square formation is limited in its application, since there must necessarily be the same number of replications as there are treatments, thus limiting the size of the experiment to five, or at most six, treatments. Moreover, it is often difficult to arrange an experiment in the form of a square. Fisher has suggested that the same type of analysis may be applied to an arrangement where the blocks, instead of being arranged one below the other, are situated side by side in a horizontal direction. The resultant yields may be tabled in the form of a "Latin Square," and the analysis proceeded with in the ordinary manner. The variation in the yield of the "row" totals allows for the soil gradient errors, and the variation in the "column" totals gives a measure of portion of the irregular soil variations within the blocks.

At Werribee both the R.B. and the L.S. methods have been tried with great success. Tests with cereals do not lend themselves to the L.S. formation, since the teams used in the field operations necessitate wide headlands between blocks. Thus the modified trial with blocks side by side has been used for experiments with four or five treatments. Where six or more factors are to be tested, the R.B. has been most useful. If the small 2-ft. path is to be used, it is important to note the need of a similar date of maturity for the varieties in any one trial. Even if the grouping of varieties was not rendered necessary by this fact, it has been found desirable for other reasons to group the varieties into early, mid-season, and late sections, and to conduct separate trials for each series.

It may not be out of place to indicate here the manner in which this "analysis of variance" lends itself to a very wide field of appli-

Table IV.—A Comparison of Two Trials (a Beavan and a R.B.) on Adjacent Areas at Werribee, 1930.

Considerations.	Beavan Trial.	R.B. Trial.
Area required for 6 replications of 3 varieties and the control	1·20 ac.	·82 ac.
Number of plots	36	24
Error obtained for the comparison between any 2 varieties	2·59%	2·48%
Intercomparison between varieties ..	Not always justified	Comparison justified
Demonstration and observation ..	Difficult, except on pairs of varieties	Good for all varieties in any one block
General execution and calculations of results	In favour of Beavan trial	

cation. The following cases illustrate the way in which it may be applied:—

(*a*) *Uniformity Trials.*—The errors characteristic of certain types of crops are generally determined from some class of uniformity trial. Although these areas are chosen on typical land and from an apparently even area of crop, standards based on "eye judgment" are proverbially of the coarsest, and it is generally found that the yields show material differences in various portions of the area concerned. Particularly is this the case where gradual soil fertility gradients occur from side to side of the field, since though the individual differences between adjacent areas are small, the cumulative effect over larger distances may be quite considerable. It has been the custom to calculate the error from the variation shown by all the plots in the uniformity trial, and it therefore becomes possible, by using the analysis, to resolve the original error into two portions—(*a*) that due to the soil gradient, and (*b*) that due to the random variation. This latter error is likely to be more constant for any particular crop, and it is therefore of more value in indicating the optimum size of plots and number of replications desirable. The treatment of the results from the original Werribee trial shows that the S.D. of 8 per cent. obtained can be reduced to 6 per cent. by this method. (See Appendix.)

(*b*) It is customary, in the comparison of different types of pasture or crops, where it is impracticable to measure the total produce, to estimate the contents, whether of yield or of composition of the field, by taking a certain number of samples over the area concerned. If, as often happens, the area shows a fertility trend from one side to the other, the error of sampling will be increased. As it is usual to take the samples on some organized scatter over the area, it is permissible to group the samples into certain blocks. If, in the treatment of the results, an analysis of variance be used, due allowance may be made for soil gradient variation, with a consequent reduction in the error of the estimation by the sampling.

(*c*) *Yield Census Studies.*—The third type in which the analysis has been most useful is in the case of "Field Census" studies. In the course of this work, it is necessary to measure certain yield characteristics of the variety or treatment under consideration. On account of soil variations, the plots of the varieties must be replicated, either in the form of a Beavan trial for a comparison of two varieties, or, where more than two are used, in some form of R.B. or L.S. The custom is to obtain the yield factors from observations on a number of samples taken from each plot. In the analysis of the results, the total variation separates itself out as follows (*see* Appendix):—

Total Variation
- Between Plots
  - Due to variety
  - Due to soil gradients
  - Due to other causes. (random error of the plots.)
- Within Plots (error of sampling).

The total error of the experiment is in this case a composite of the error between plots and the error of sampling each plot. With the knowledge of the comparative values of these two components, attempts to decrease the total error may be directed along the most profitable line—if the former error be the larger, by increasing the number of replicates, or if the latter, by increasing the number of samples per plot. This type of work is of very wide

Table V.—Analysis of Variance of a Germination Count on Populations of a Gypsum Trial, Werribee, 1930.

Variation Due to—	Degrees of Freedom.	Sum of Squares.	Mean Square.	½ loge. (Mean Square).
Between plots—				
Rows	3	51·27	17·09	..
Columns	3	52·15	17·38	..
Treatments	3	526·15	175·38	1·4322
Remainder (Error of plots)	6	129·35	21·56	·3841
	15	758·92	..	..
Within plots (Error of sampling)	192	6,867·85	35·77	·6374
Total	207	7,626·77		

application, and the figures in Table V. show its application to a gypsum test at Werribee.

(*d*) *Complex Experiments.*—It was essential with the larger errors of the older types of experiment, that the issue should be made as simple and as clear as possible, and that the questions should be determined one at a time. The land, labour, and time involved in a series of trials on any complex question, such as manuring of a crop, were very considerable. Separate tests would have to be conducted with different manures singly and in their various combinations, and applied at different rates per acre. By the use of this "analysis" of the results from a R.B. trial, it has been possible to combine all these questions into one experiment of reasonable dimensions, and to measure at the same time the degree of interaction between the manures. Reference to Fisher's articles will amplify these points. As an example of a more simple type, we may profitably consider a problem whose solution has been attempted at Werribee. Wheat varieties differ largely in their size of grain, and therefore yield trials sown at a definite number of pounds of seed per acre may handicap the large-grained and favour the small-grained varieties through the effect on the number of plants per acre. An exploratory trial was therefore designed to test extreme cases of grain size in both early and late types of varieties. Four varieties were chosen—Currawa as a large-grained, and Federation as a small-grained late wheat; while Nabawa as a large-grained, and Rajah as a small-grained variety were the early types. These were tested at three rates of seeding corresponding to—(*a*) 16 grains per foot; (*b*) 12 grains per foot (the normal number of grains sown); and (*c*) 8 grains per foot. All twelve possible combinations of variety and rate of seeding comprise the members of a single block, and the blocks are replicated four times. At harvest, the results will be analyzed as follows:—

- Total Variation
  - Between Treatments
    - Due to variety
    - Due to rate of seeding
    - Due to interaction between variety and rate of seeding.
  - Within Treatments
    - Due to soil gradients (block variation)
    - Due to random plot variation.

In this manner, the relative yields of the varieties, of the rates of seeding and of the effects of interaction may be determined.

Other Consideration of Plot Design.

Quite apart from these considerations of the actual lay-out of plots lies that most important field relating to the questions of size and shape of plots, the number of replications, and many other problems. Each of these factors demands careful thought, the resultant conclusions varying not only with the class of crop, but also with the peculiarities of the district, the soil, and the experiment. For instance, it is of little use attempting to reduce the error of a given trial to 2 per cent. if the outside rows of the plots introduce an error of 10 per cent. in the response of the different varieties. Furthermore, it would be ridiculous to design an experiment to give an accuracy of 1 per cent. when the treatment in question would only be of economic value if it gave a 10 per cent. increase over the control. It is necessary in this work, as in many other subjects, to ask ourselves right at the beginning: "What are the questions to be answered? What is their nature, and their probable value?"; and then to design the experiment so that the statistics may be applied as an aid in the valid establishment of the facts we seek. As Johannsen has said, "We must treat facts with mathematics, not as mathematics."

It may help our experimenter, therefore, if some space is devoted to a consideration of these other important problems which have played their part in the development of accuracy.

Size of Plot.—Uniformity trials are of great assistance in obtaining knowledge on these points. Although the greatest accuracy would demand that such trials should be conducted on all areas under consideration, the remarkable uniformity of the conclusions derived from these trials, when conducted in various parts of the world, enables us to draw certain conclusions which will apply generally. Considering the size of a unit plot for a cereal trial, it is generally conceded that a plot of 1-40th acre is the most economical. With bigger plots, the area of the trial becomes too extensive, and the soil variants play too big a part; with smaller plots, the random errors dominate the position. For irrigated lucerne at Werribee, the optimum size of plot would appear to be slightly smaller, in the region of 1-60th acre. In a maize uniformity trial at Gatton, Queensland (26), a plot of 1-18th acre in size was indicated. With certain other crops, such as potatoes, it is our experience that a smaller size of plot would be the most economical.

As far as pasture is concerned, the same general conclusions cannot be drawn, for whereas cereal crops are of a somewhat similar homogeneity throughout the world, pastures vary tremendously both in species composition, in the constantly altering relation of these species one to the other, and in the type of management. Thus a recommendation from a Rye grass-white clover stand in New Zealand may not apply to a Danthonia-native trefoil complex in Victoria. A paper published recently by Davies, in South Australia (7) working on an Erodium dominant, Danthonia, Echium sub-dominant pasture indicated that the errors of sampling on this heterogeneous complex were considerably larger than with wheat. The optimum size of plot was found to be 1-200th acre, while the S.D. of such a size of plot was of the order of 14 per cent.

Number of Replications.—With regard to the number of replications, there are two factors which have to be considered—(*a*) the variability of the material. and (*b*) the size of the differences to be measured. Most authorities are agreed that for cereals from four to six replications are necessary to measure differences of the order of 10 per cent. For more variable material such as pastures, a greater number of replications would be necessary. For horticultural experiments Hoblyn (13) quotes a S.D. of 25 per cent. for his unit-sized plot of one tree, and concludes that he would need eight replications to measure 20 per cent. differences in treatments. In the case of R.B. trials, where the number of treatments is large, four or five replications would be ample.

Shape of Plot.—Recommendations as to the shape of plot have varied greatly. Hall and Mercer (18) indicated that long and narrow plots were the best, while certain other investigators found that long and narrow plots had no advantage over square-shaped areas. The conclusions from the Werribee uniformity trial supported Hall and Mercer's recommendations, with the proviso that the axis of the long narrow plots should not be taken in a direction at right angles to the line of the soil gradient. The explanation of these apparent anomalies lies in the type of soil error experienced in the trials. Considering first the random variations of soil, it has been observed frequently these "patches" tend to occur in more or less circular shapes. These would be spread more evenly over a series of plots if the shape tended to be long and narrow. (See Fig. 7.)

With regard to the fertility gradient variation, the position is not so simple, since the direction of such a gradient is not always known. Christidis has summarized the position in the following conclusions (4):—

(*a*) In no case can square plots be more uniform than long and narrow ones.

(*b*) The smaller the ratio of the width to the length, the more uniform the plots, but a limit is reached in the reduction of the width on account of practical considerations.

(*c*) Uniformity of results also depends on the angle between the line of the maximum soil gradient and the length of the plots. The best results are obtained when this angle (*a* in the diagram) approaches 0 deg.

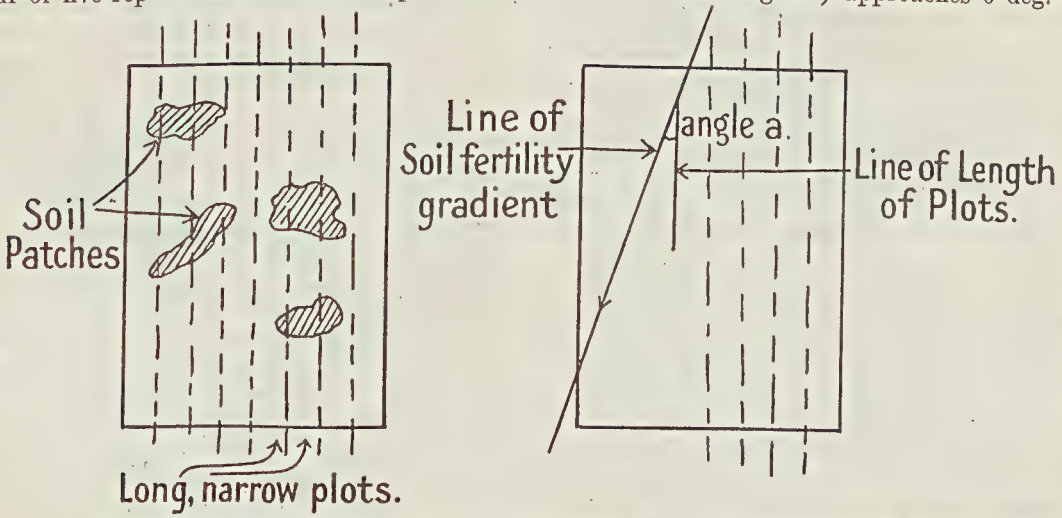


Fig. 7.—Diagram showing the two types of soil errors in relation to plot shape.

Where the direction of the soil gradient is not known, the best results will be obtained by a design which groups long plots into as compact an area as possible.

Border Effects.—Considerations of border effects on plots, whether due to competition between neighbouring plots or to the differential effect of the path on the outside row, may play an important part in field trials. The use of a stripper in cereal trials, as is common in Australia, necessitates a path of 24 inches, or thereabouts, so that the problem of inter-plot competition is seldom met with. Where labour is plentiful, any effect of the path on the outside row may be eliminated by cutting one, or preferably two, outside rows of each plot at harvest, but where the trials are at all extensive, the expense involved in this practice is a serious item. The degree of differential effect between varieties will alter with the crop in question, with the district and season, and with the size of path. As usual, information on these points is scarce. Arny and Hayes (1) with a path of 18 inches, found that errors introduced from this cause varied from 7.5 to 15.8 per cent. for eleven varieties of oats, and from 14.1 to 23.5 per cent. for five varieties of wheat. A trial at Werribee on Free Gallipoli wheat showed that a path of 14 inches increased the yield of a nine-hoe plot by 8.5 per cent., while a 5-ft. path increased the yield by 17.7 per cent. In other districts, e.g., the Wimmera black lands, the effect is obviously much greater than this. Trials are in progress to determine the differential effect on varieties under these conditions. It appears, therefore, that the consensus of opinion is in favour of cutting outside rows where the available labour will allow.

Climate.—In any consideration of the errors of field trials, the discussion would be inadequate if due allowance were not made for seasonal variations from year to year. The most suitable variety for a given district is the one which gives the highest yields over a period of years. No type of plot technique will provide more than the definite knowledge that a certain variety or treatment is the best on that particular type of soil under that given set of climatic conditions. It therefore becomes necessary to repeat any experiment over a series of years. Experimenters are ignorant of the errors involved, when in designing yield trials to give one or two per cent. accuracy, they are satisfied with one or even two years' trial.

Measurement of the variation due to season is rather difficult of attainment, since in practice it is impossible to repeat a series of plots under exactly similar soil conditions for several years. Even if the plots were sown on exactly the same site in successive years, the resultant decrease in yield due to the lack of rotation is well known to Australian workers. Resort has to be made then to conditions as similar as possible. Engledow and Yule (8) have estimated that the S.E. of cereal variety trials due to the weather alone is in the region of 8 per cent. The figures for the Victorian conditions are given in Table VI.

The figures for the composite error of soil and climate (E_{w+g}) and for the soil error alone (E_g) were obtained from a study of the Beavan trials conducted during the years 1927-1930 at the three stations mentioned. Since sixteen varieties have been tested against their appropriate controls during this time, five at Longerenong, five at Rutherglen, and six at Werribee, the figure from the S.E. of soil variations should be fairly reliable. Similarly, since the seasons at the three stations have varied widely, the figure for the total variation of soil and climate E_{w+g}, should give a fair indication of the differential effect of season on variety. The difference between these two values gives the S.D. of climatic effect in any one year. The English conclusions over a period of nine years are also included.

Trials conducted in areas of greater variability of rainfall, which is the major climatic factor in the culture of Victorian cereals, would have a proportionately greater error for seasonal variation. Such areas would include the Mallee districts.

It is obvious then that there is just as much need for a replication of any given experiment over a period of years. A repetition for four years would reduce the error for seasonal variation from 3 to 4 per cent., which would then be comparable with that of the soil error. Suggestions to obviate this necessity have been made by Engledow and Yule, who advocate two or more times of seeding in any one year, and it is possible that much time may be saved in this manner. It must be remembered, however, that the English climate differs materially from that in Australia, that the growing period of the plant is much longer and that rainfall is not a major factor. Thus the varying times of seeding may not play the

TABLE VI.—THE ERRORS OF SOIL AND CLIMATE FOR THE BEAVAN PAIRED TRIALS IN VICTORIA, 1927–1930.

Station.	Composite Error (Soil and Season).	Soil Error.	Climate Error.
	E_{w+g} %	E_g %	E_w %
Werribee	9·19	1·97	8·97
Rutherglen	6·02	2·48	5·49
Longerenong	6·29	2·48	5·77
English figure	..	..	7·74

same role in simulating the seasonal effect under Australian conditions.

In conclusion, it may not be out of place to stress the fact that the statistician can only indicate the lines along which an experiment may be designed to enable him to measure certain variables and to exclude others. The error which he calculates is purely a measurement of the variation of the yields of the plots. This variation is a composite, not only of the random patches of soil, but also of the irregular seeding, manuring, and harvesting of the plots. It is therefore just as important for the investigator to select even areas of land for his trial, to make certain that the seed of his varieties is comparable, and that the drilling, harvesting, and weighing of the produce is carried out with suitable care. It is therefore essential that where adjustments have to be made between theoretical desirability and practical suitability, the latter should have preference.

And if, in spite of the utmost care in the planning and execution of experiments, an abnormal season finds soggy patches that were absent when the trials was designed, or we find after a season of endeavour that the assistant has accidentally emptied our special control pots (17) we may comfort ourselves with the thought that—

> "The best laid plans of mice and men,
> Gang aft agley."

and perservere.

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Appendix.

Learning from their own experience that one example is worth a page of theory, the authors have included the following typical examples of the more important methods described in the article :—

EXAMPLE 1.—A BEAVAN TRIAL BETWEEN RANEE AND A NEW SELECTION 4H, WERRIBEE, 1929.

Method .. .. .. Eight pairs of 1/40th ac. plots in the order ABBAABBA.

	Ranee.	4H.	Diff. (x).	Deviation (*d*) from Mean.	d^2.
	lb./plot	lb./plot			
	43·0	49·0	+ 6·0	+ 0·37	0·137
	39·5	48·0	+ 8·5	+ 2·87	8·237
	42·5	46·5	+ 4·0	− 1·63	2·657
	39·5	45·5	+ 6·0	+ 0·37	0·137
	45·0	44·0	− 1·0	− 6·63	43·957
	40·0	50·5	+ 10·5	+ 4·87	23·717
	40·0	46·0	+ 6·0	+ 0·37	0·137
	38·5	43·5	+ 5·0	− 0·63	0·397
Total	328·0	373·0	+ 45·0	+ 8·85	79·376
Mean	41·0	46·6	5·63	− 8·89	..
Mean (bus./ac.) ..	27·4	31·1	3·7	..	..

An alternative shorter method of obtaining " d^2 " depends on the use of an arbitrary mean. Readers are referred to the text-books for the theory of the procedure. If the arbitrary mean be assumed to be 0 in the above case, " d^2 " may be obtained by subtracting the product of the total and the mean of the differences (x) from the sum of the squares of each difference ; or alternatively by subtracting the quotient obtained by dividing the square of the total by the number of plots comprising the total.

Thus the sum of the squares = 332·50

Subtract $(45·0 \times 5·63)$ or

$$\frac{(45·0^2)}{8} = 253·125$$

$$79·375$$

$$\text{The S.D.} = \sqrt{\frac{\text{Sum } d^2}{n}} = \sqrt{\frac{79·375}{8}} = 3·15.$$

$$Z = \frac{M}{\text{S.D.}} = \frac{5·63}{3·15} = 1·79.$$

Referring to the " Z " table, when $Z = 1·79$ and $n = 8$, the odds on the significance of the difference are 999 : 1. The trial has indicated therefore that the new selection 4H is significantly better than Ranee, and has this year beaten it by 3·7 bus./ac.

N.B.—In calculating the S.D. of the difference, " n " indicates the number of pairs of plots. " n—1 " is never used in this method in arriving at the " Z " factor.

This " Z " factor must not be confused with the " z " of Fisher's.

EXAMPLE 2.—A RANDOMIZED BLOCK EXPERIMENT WITH FOUR SELECTIONS OF WHEAT (VAR. GALLIPOLI), WERRIBEE, 1930.

Type of experiment .. .. .. 5 R.B. of four varieties.
Area of plot .. .. .. 1/40th ac.
Varieties .. .. .. A. Free Gallipoli, 58—1—6.
B. Gallipoli 70G.
C. Gallipoli 76I.
D. Gallipoli 86I.

Plan ..					Yields ..				
	D	B	C	A		29·3	33·3	30·8	32·2
	B	A	C	D		33·0	34·0	34·3	26·0
	D	A	B	C		29·8	34·3	36·3	35·3
	B	A	D	C		36·8	35·0	28·0	32·3
	D	C	B	A		28·8	35·8	34·5	36·5

lb. per plot.

Grouping the results into their varieties, we have—

Variety	A.	B.	C.	D.	Total.	
Block 1	32·3	33·3	30·8	29·3	125·7	
„ 2	34·0	33·0	34·3	26·0	127·3	
„ 3	34·3	36·3	35·3	29·8	135·7	
„ 4	35·0	36·8	32·3	28·0	132·1	
„ 5	36·5	34·5	35·8	28·8	135·6	
Total ..	172·1	173·9	168·5	141·9	656·4	
Mean ..	34·4	34·8	33·7	28·4	..	G.M. 32·8

The sums of squares are obtained as follows :—

(*a*) *Total* (all plots).—It is considerably easier with these large numbers to use the shorter method of obtaining the squares of the deviations from the mean. Hence the total sum of squared deviations is obtained by summing the squares of each plot, and subtracting $\frac{656{\cdot}4 \times 656{\cdot}4}{20}$ (= 21,543·05).

The crude sum of squares	= 21,725·22
Subtracting	21,543·05
Total sum of squares	= 182·17

(*b*) *Blocks* (soil gradient variation).—This is similarly obtained by summing the squares of each block total dividing by 4, since each block total is a sum of 4 plots, and then subtracting the same figure.

The crude sum of squares of blocks	= 86,258·04
Dividing by 4	21,564·51
Subtracting	21,543·05
Sum of squares of block variation	= 21·46

(*c*) Similarly with the *variety variation.*

Crude sum of squares of variety totals	= 108,387·48
Divide by 5	21,677·50
Subtracting	21,543·05
	134·45

The crude sum of squares is divided by 5 in this case, since the variety totals represent the sum of 5 plots.

(*d*) The sum of squares due to *random variation* is found by subtracting (*b*) + (*c*) from the total sum of squares.

The number of " degrees of freedom " are one less than the total number of plots, blocks, or varieties, as the case may be. The number for the random variation is obtained in the same way as for the sum of squares, i.e., by subtracting (*b*) and (*c*) from the " total " number of degrees of freedom.

The analysis of variance may now be written—

Variation Due to—	Deg. of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (Mean Square).
Blocks	4	21·46	..	..
Varieties	3	134·45	44·82	1·9376
Remainder (error)	12	26·26	2·19	·3919
Total	19	182·17	..	..

/ In the comparison of the mean squares for " variety " and for " error " by Fisher's table, the " z " factor for P = ·05, and $n_1 = 3$, $n_2 = 12$, is ·6553. The observed difference of 1·5455 (1·9376 − ·3919) is well above this range, thus indicating that the variation due to varieties is significantly greater than that due to random error.

The S.E. of a mean of 5 plots = $\sqrt{\frac{2{\cdot}19}{5}}$ = 0·661.

The yields may therefore be summarized as follows :—

Variety.	Lb./plot.	Bus./ac.	
Gallipoli 70G	34·8	23·2	
Free Gallipoli	34·4	22·9	
Gallipoli 76I	33·7	22·5	
Gallipoli 86I	28·4	18·9	
Mean yield	32·8	21·9	S.E. = ·66 lb./plot (2·01 %).

The trial has indicated therefore that the two selections, 70G and 76I, are not significantly better than the Standard Free Gallipoli, while the third selection, 86I, is definitely worse.

Example 3.—The Analysis of Variance as Applied to the Werribee Uniformity Trial, 1927.

As space will not permit of the inclusion of the yields of the 160 individual plots, the analysis of variance only will be given. The procedure is exactly similar to the above example, except, of course, that there will be no variance due to " variety ".

Analysis of Variance—

Due to—	Deg. of Freedom.	Sum of Squares.	Mean Square.	½ log$_e$.
Columns	9	6,041·1	671·23	2·1032
Rows	15	2,666·4	177·76	1·4391
Remainder (error)	135	9,100·0	67·33	·9535
Total	159	17,807·5	..	..

Reference to the " z " table again shows that there was a significant effect of the gradient factor in both " rows " and " columns." We may expect, therefore, a significant decrease in the random error as obtained by this method.

The S.D. (of a single result or plot) = $\sqrt{67·4} = 8·21$.

The average yield was 135·9 oz., thus the S.D. = 6·05%, as compared with 8·02%, without any reduction for soil gradients.

In calculating the values of ½ log$_e$, it is advisable for simplicity to divide the mean squares by 10 (or some multiple), so as to reduce the lowest number to a value between 0 and 10.

Example 4.—An Analysis of a Population Count on a Gypsum Trial, Werribee, 1930.

Type of experiment .. .. A Latin square of four treatments.
Area of plot .. .. .. 1/40th ac.
Treatments .. .. .. A. No manure.
B. An application of 10 cwt. per acre of gypsum.
C. 1 ton gypsum.
D. 2 tons gypsum.
Sampling .. .. .. 13-yard samples per plot.
Plan .. .. .. A B C D . C D B A . B A D C . D C A B .
Results .. .. .. Numbers of plants per yard sample.

Plot ..	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
	36	33	27	23	32	21	35	19	26	39	36	27	30	25	22	30	
	30	29	25	39	22	27	21	21	29	33	46	26	30	28	23	21	
	26	29	36	14	27	27	28	22	34	30	36	25	30	28	23	29	
	20	24	23	22	43	38	24	22	21	24	25	23	33	30	25	26	
	26	32	35	36	33	42	18	21	34	23	30	34	31	31	23	27	
	29	22	42	36	26	30	25	26	30	17	35	29	31	23	38	24	
	15	30	27	25	31	29	33	36	40	26	21	26	35	24	17	19	
	21	27	26	34	22	34	29	26	29	14	34	32	19	32	21	21	
	25	25	19	28	24	31	31	15	28	25	22	23	20	22	34	30	
	30	25	29	38	29	31	20	23	26	21	40	27	22	30	28	26	
	28	33	32	37	25	31	24	34	24	27	38	36	25	29	20	37	
	37	25	27	24	42	39	37	25	29	37	21	29	29	30	25	35	
	27	25	22	25	26	21	22	23	30	20	28	23	27	40	30	29	
Totals ..	350	359	370	381	382	401	347	313	380	336	412	360	362	372	329	354	Total 5,808, G.M. = 27·9

Now in considering the analysis of variance, the text indicates that the *total variation* of all the samples may be divided into two portions, that due to the *variation between the plots*, and that due to the *variation within the plots*. These in turn may be further subdivided.

(1) The first step is to obtain the *total variation* from the sum of the squares of the deviations from the mean of all the individual samples. Using the short method again, we have—

The total sum of squares of all samples	= 169,804·00
Subtracting $\frac{5{,}808 \times 5{,}808}{16 \times 13}$	= 162,177·23
Thus the sum of squares for total variation	= 7,626·77

(2) The second step is to consider the *variation between the plots*. Since this system of plots was planned as a L.S., this portion may be separated into that due to the "row" variation, that due to the "columns," that due to the "treatments," and finally the remaining portion which is due to "random errors" between the plots. The procedure is similar to that of the example of a R.B.

Grouping the results in the form of a L.S., we have—

				Totals.
350	359	370	381	1,460
382	401	347	313	1,443
380	336	412	360	1,488
362	372	329	354	1,417
Totals 1,474	1,468	1,458	1,408	5,808 G.M. = 27·9

Treatment totals .. .. .. A = 1,328
B = 1,440
C = 1,484
D = 1,556

The total *variation between plots* is obtained from the plot totals. Thus—

The sum of squares of plot totals	= 2,118,170·00
Divide by 13	= 162,936·15
Subtracting the same quantity as before	162,177·23
Thus the total var. between plots	= 758·92

Subdividing this—

	Rows.		Columns.		Treatments.	
	1,460	2,131,600	1,474	2,172,676	1,328	1,763,584
	1,443	2,082,249	1,468	2,155,024	1,440	2,073,600
	1,488	2,214,144	1,458	2,125,764	1,484	2,202,256
	1,417	2,007,889	1,408	1,982,464	1,556	2,421,136
Totals		8,435,882		8,435,928		8,460,576
Divide by 13 × 4 ..		162,228·50		162,229·38		162,703·38
Subtracting ..		162,177·92		162,177·92		162,177·92
		51·27		52·15		526·15

When subtracted from the total variation between plots, these leave a sum of squares (= 129·35), which is due to the random causes.

(3) The third step of obtaining the *variation within plots* may be arrived in either of two ways. The simplest method is to subtract the variation between plots from the total variation between all the samples.

Thus 7,626·77 — 758·92 = 6,867·85.

The alternative method involves the actual determination of the variation within each plot, and since the procedure is not very involved, the method is useful in checking the arithmetic of the whole analysis.

Each plot is taken separately, and the sum of the squared deviations of each sample from the plot mean is obtained. The total variation within the plots is then simply the total of the various sums of squares obtained from the various plots. The procedure is as follows:—

Taking Plot 1 as an example, sum the squares of each sample (= 9,862·0), and subtract the $\frac{\text{square of the plot total.}}{13}$ (= 9423·08)

Thus—

Plot.	Crude Sum of Squares.	$\frac{(\text{Plot Total})^2}{13}$	Sum of Squares.
1	9,862·00	9,423·08	438·92
2	10,073·00	9,913·92	159·08
3	11,012·00	10,530·77	481·23
4	11,901·00	11,166·23	734·77
5	11,778·00	11,224·92	553·08
6	12,849·00	12,369·31	479·69
7	9,695·00	9,262·23	432·77
8	7,923·00	7,536·08	386·92
9	11,388·00	11,107·69	280·31
10	9,340·00	8,684·31	655·69
11	13,808·00	13,057·23	750·77
12	10,180·00	9,969·23	210·77
13	10,376·00	10,080·31	295·69
14	10,908·00	10,644·92	263·08
15	8,375·00	8,326·23	408·77
16	9,976·00	9,639·69	336·31
	169,804·00	..	6,867·85

The analysis of variance is then established as follows :—

—	Degrees of Freedom.	Sums of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (Mean Square).
Between plots—				
Rows	3	51·27	17·09	..
Columns	3	52·15	17·38	..
Treatments	3	526·15	175·38	1·4322
Remainder	6	129·35	21·56	·3841
(Error between plots)	15	758·92	..	..
Within plots	192	6,867·35	35·77	·6374
(Error of sampling)				
Total	207	7,626·77		

Reference to Fisher's "z" table shows a significant difference in favour of treatments over the errors. The further comparison between the two types of error show no significant difference. We may conclude, therefore, that the experiment has been satisfactorily designed.

The S.E. of a mean of 4 plots $= \sqrt{\frac{21·56}{4 \times 13}} = ·644 = 2·31\%$.

The S.E. of 13 samples/plot $= \sqrt{\frac{35·77}{13}} = 1·66 = 5·94\%$.

The composite S.E. thus $= \sqrt{\frac{21·56 + 35·77}{4 \times 13}} = 1·05 = 3·77\%$.

The result of the population count may, therefore, be written as follows :—

Treatment.	Average Number Plants/ft.	Remarks.
A. No Gypsum	8·51	
B. 10 cwt./ac. Gypsum ..	9·23	Although there is no significant difference between these gypsum treatments they show significance when compared with the No Gypsum plot
W. 1 ton/ac. Gypsum ..	9·50	
D. 2 ton/ac. Gypsum ..	9·97	
Mean	9·33	S.E. = ·35 (3·77%)

The experiment, therefore, has successfully demonstrated that the application of gypsum has increased the germination of wheat seed under Werribee soil conditions.

Packing of Pears

Chart for Williams Bon Chretiens

The following method of packing Williams Bon Chretien pears in the 8-inch standard pear case (18 inches long by 11½ inches wide by 8 inches deep—inside measurements) is recommended by Mr. B. P. Krone, Fruit Packing Instructor, Department of Agriculture:—

Size.	Pack.	Layer.	No. of Layers.	Total No. of Pears.	Remarks.
2¼″	3–3	5×5	5	150	Pack more loosely than usual
	3–3	6×5	4	132*	Normal pack
2½″	3–3	5×5	4	120*	Normal pack
	3–3	5×4	4	108*	Normal pack
	3–3	4×4	4	96*	Normal pack
2¾″	3–3	4×3	4	84*	Pack more loosely than usual
3″	3–2	5×4	3	68	Pack more tightly than usual
3¼″	3–2	4×4	3	60	Normal pack

NOTE.—The counts marked (*) are the most suitable for export fruit. The count, and not the diameter, should be branded on one end of each case.

When to Pick Pears.

The best time to harvest pears is indicated by—

1. The change of the ground colour of the skin from dark-green to pale green.
2. The changing of the dots or lenticels from a light to a dark or corky appearance.
3. The well-filled-out appearance of the pear.
4. The ease with which the fruit can be separated from the spurs when harvesting.

In a pear ready for harvesting the juice immediately rushes to the surface when a slice is cut from the fruit; if it remains dry the fruit is still immature.

Points on Packing for Export.

Pack pears with a bulge of 1½ to 2 inches above the top of the case before lidding.

If lids are in two pieces, keep them as close together as possible to prevent cutting the fruit.

Wood-wool or corrugated cardboard should be used at top, bottom, and sides of the case when packing.

In all instances, the W.B.C. pear should be pre-cooled before export.

Wire-tie all cases to prevent breakages and ullage in transit.

Temperatures.

Pears should remain in cool store at least three days before packing; the temperature should be 29-31° F.

Temperature of the truck before loading should be 50-56° F.

The core temperature of pears at loading should be 30-35° F.

If these suggestions be followed closely the temperature of the truck upon arrival at the boat should be 40-45° F., with the core temperature of the pears between 35 and 40° F.

On no account should the temperature of Williams Bon Chretien pears on arrival at the boat for export be more than 40° F.

HARPER'S "STAR" RICEMEAL

A great many Farmers are now using

HARPER'S "STAR" RICEMEAL

both for fattening Pigs and feeding Dairy Cows.

It contains all the most nutritive constituents of Rice, and its Protein and Fat content indicate its value as a Stock Food.

PROTEIN	11·5%
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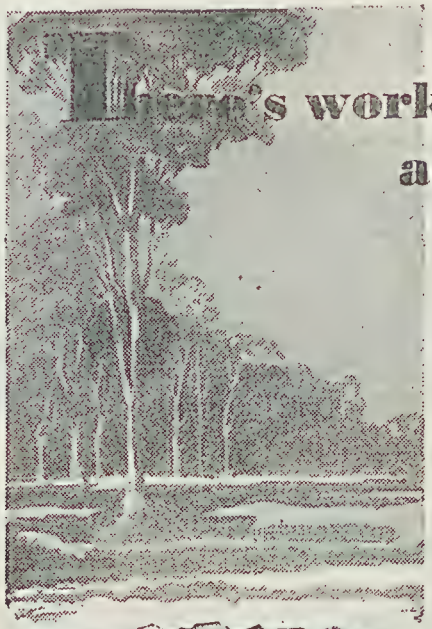

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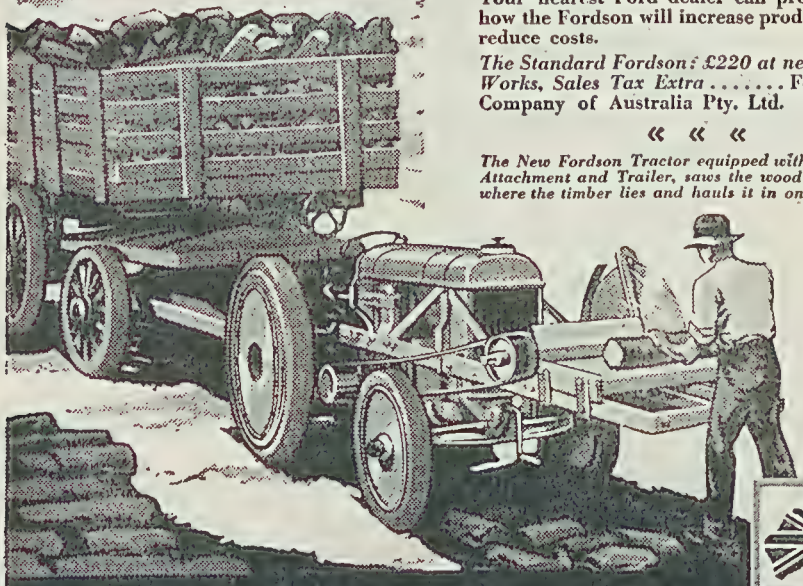

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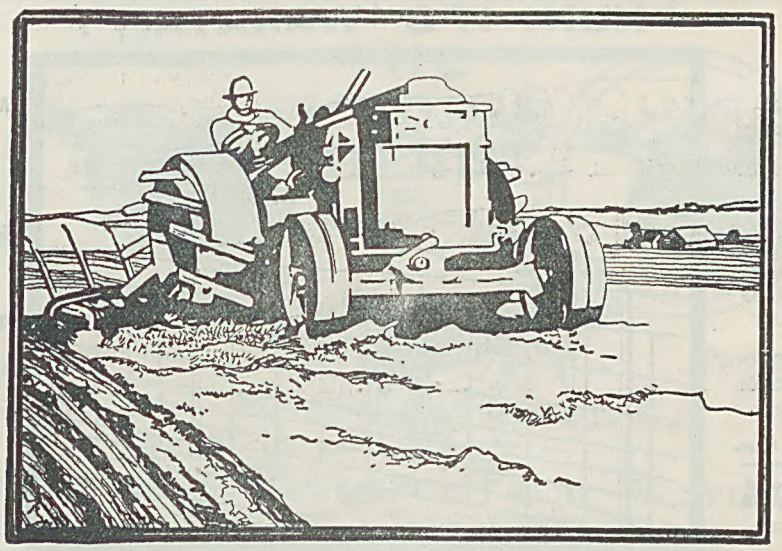

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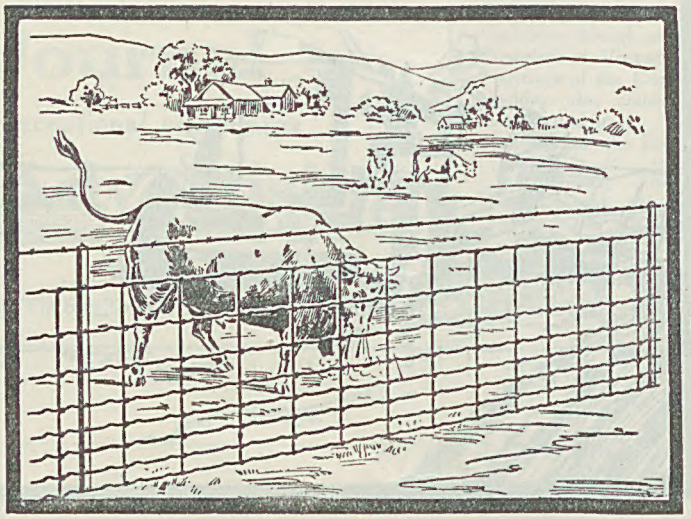

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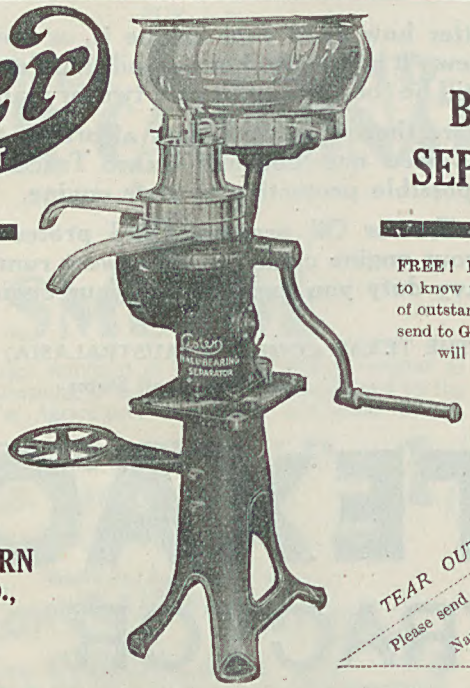

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